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# ANATOMISCHE UNTERSUCHUNGEN ÜBER DIE VERTEILUNG DES EPIDURALEN FETTES IM LUMBALRÜCKEN[1]

## Ein Beitrag zur myelographischen Differentialdiagnostik

von

*Helge Sjövall*

Mit jedem neuen Gebiet, das sich dem chirurgischen Handeln erschliesst, erhebt sich das Bedürfnis nach exakten anatomischen Erkenntnissen von einer Art, die oft genug bis dahin nicht aktuell gewesen waren. So auch jetzt, wo die *Zwischenknorpelscheibenprolapse* in die chirurgische Interessensphäre einbezogen sind. Vorbedingungen einer exakten Diagnose dieser Veränderungen ebenso wie ihrer Therapie sind eingehende Aufschlüsse beispielswiese über den Bau der Zwischenknorpelscheiben, die Anatomie der Intervertebralöffnungen, die makro- und mikroskopische Gestaltung der Ligamenta flava usw. — Daten, die vor der chirurgischen Epoche kaum für den Anatomen vom Fach grösseres Interesse besassen und über die aus dem anatomischen Schrifttum wenig zu erfahren ist. Auf den hier angedeuteten Gebieten sind unsere Einsichten in den letzten Jahren auch nicht zum wenigsten durch Arbeiten von klinischer Seite (FRIBERG u. a.) erweitert und vertieft worden.

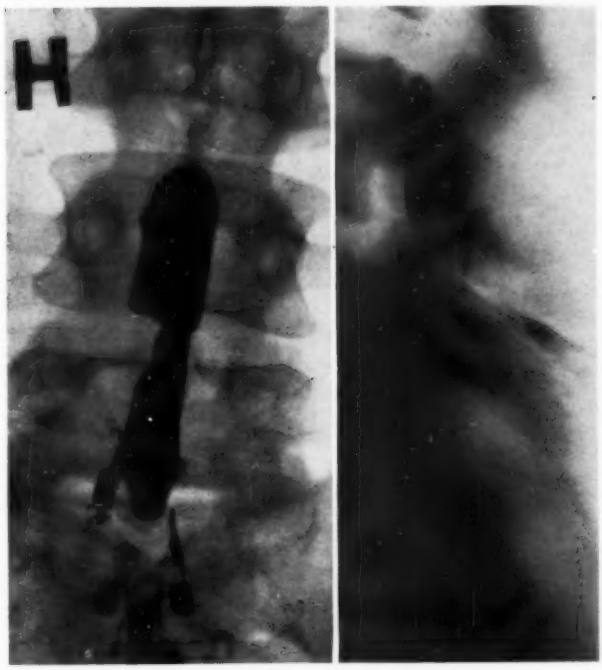
Das wichtigste Hilfsmittel bei der Diagnostik des Discusprolapses ist die *Myelographie*. Unter 44 Fällen sah z. B. FRIBERG (1941) in 39 Fällen ein positives Röntgenbild, und in 2 der restlichen 5 Fälle konnte

[1] Bei der Red. am 24. XI 1942 eingegangen.

Aus der Orthopädischen Universitätsklinik zu Lund (Chefarzt: Med. Dr. STEN FRIBERG).

man auf Grund mangelhafter Ausfüllung der Wurzelscheiden örtliche Veränderungen an den Wurzeln vermuten; in den 3 Fällen mit negativem Röntgenbefund stellte es sich bei der Operation heraus, dass der Bruch lumbosakral gelegen war und die erste Sakralwurzel lateralwärts des Duralsackes beteiligte. Bei der Myelographie können wir für die diagnostische Fragestellung nur eine Veränderung der Form des Duralsackes registrieren, und eine genaue Kenntnis von der Gestaltung des Spinalkanals ist selbstverständlich bei der Bewertung der Myelogramme von entscheidender Bedeutung. Ein Faktor, der für die Formgestaltung des Rückenmarkkanals im Lumbalrücken evtl. von Bedeutung ist und der — soweit ich habe finden können — bisher keine Beachtung gefunden hat, ist die Entwicklung und Verteilung des *epiduralen Fettes*. Es liegt indessen auf der Hand, dass dieser Faktor für die Begutachtung der Myelogramme überhaupt und für die Diagnostik der Zwischenknorpelscheibenbrüche insbesondere von grosser Bedeutung sein kann. Das epidurale Fett könnte nämlich, wenn es eine grössere Mächtigkeit hat oder haben kann, ein Polster bilden, in dem ein Prolaps unter gewissen Umständen sozusagen verschwinden könnte, ohne die charakteristischen Eindellungen des Duralsackes zu bewirken. Andererseits könnte eine abnorme Entwicklung des epiduralen Fettes unter gewissen Umständen Bilder geben, die fälschlich als durch einen Bruch verursacht angesprochen werden können. Durch die *epidurale Myeolographie* (FORESTIER 1922, KNUTSSON 1942 o. a.) wird diese Fehlerquelle bis zu einem Grade ausgeschaltet, gleichzeitig aber weckt sie gesteigertes Interesse für die normalanatomischen Verhältnisse in dieser Gegend. Die reiche Erfahrung, über die wir nunmehr in bezug auf die myelographische Diagnostik des Zwischenknorpelscheibenbruches verfügen, dürfte wohl zeigen, dass die hier berührten Verhältnisse in den meisten Fällen keine entscheidende Rolle spielen. Dass sie jedoch dann und wann zu diagnostischen Irrtümern führen können, lehrt m. E. ein Fall, den wir an der *Lunder* Orthopädischen Klinik beobachtet haben.

*Tgb.-Nr 489/41.* 35Jähr. Frau. — Seit dem 16. Lebensjahr ständige Beschwerden durch Hexenschuss und seit 6 Jahren schwere, rechtsseitige Ischias. Wiederholte längere konservative Behandlung in einem anderen Krankenhaus blieb erfolglos. Typische Husten- und Niesschmerzen. Aufnahme am 16. 6. 1941 mit stark fixiertem, heterolog skoliotischem Lumbalrücken, pos. Laségue von 70° rechts, sonst jedoch ohne neurologische Symptome. Die *Myelographie* (Abb. 1 und 2) zeigte ein schönes positives Bild in Höhe des vierten Lendendiscus. Bei der *Laminektomie* (SJÖVALL) wurden inspektorisch und palpatorisch normale Befunde in der Region erhoben, als aber der Duralsack nach links hinübergeschoben wurde, sah man eine fingerspitzengrosse, gelbweisse, in den Spinalkanal hineinragende Bildung. Mit dem Instrument liess sie sich ohne weiteres zerdrücken und das ganze Gebilde bestand nur aus Fett. Nach Lage, Grösse und Form entsprach diese — man könnte vielleicht sagen — lipomatöse Bildung exakt dem myelographischen Bilde. Spuren von einem Knorpelscheibenbruch waren bei dem Eingriff nicht festzustellen. Im Nachverlauf trat eine Pyelitisattacke auf —die Patientin



1. 2.

Abb. 1 u. 2. Die myelographischen Ergebnisse des Falles 489/41.

hatte schon früher Cystitisbeschwerden gehabt —, im übrigen aber verlief die Rekonvaleszenz glatt und bei der Entlassung 6 Wochen später war die Frau subjektiv beschwerdefrei. — In einem Brief vom 28. 7. 1942 teilt sie mit, dass sie seit Okt. 1941 arbeitet, ohne jemals etwas von ihren früheren Rückenbeschwerden zu merken.

Dieser Fall, wo ein in den Spinalkanal hineinragender Fettkörper die Diagnose »Discusprolaps» veranlasste, bewegte mich, die Verteilung und Entwicklung des epiduralen Fettes zu untersuchen und in dieser Absicht habe ich 25 Präparate vom Lumbalrücken studiert. Die Präparate stammen von Leichen von Personen im Alter zwischen 20 und 50 Jahren.[1] Bei der Sektion wurde in gewohnter Weise der Lumbalabschnitt in toto entnommen und längere Zeit in 10-%iger Formalinlösung fixiert, um das Sezieren und die Beurteilung der anatomischen Lageverhältnisse zu erleichtern. Beim Präparieren wurde die Laminektomietechnik angewandt.

[1] Herrn Professor EINAR SJÖVALL, der mir das Material liebenswürdigerweise zur Verfügung gestellt hat, sage ich meinen ergebensten Dank.

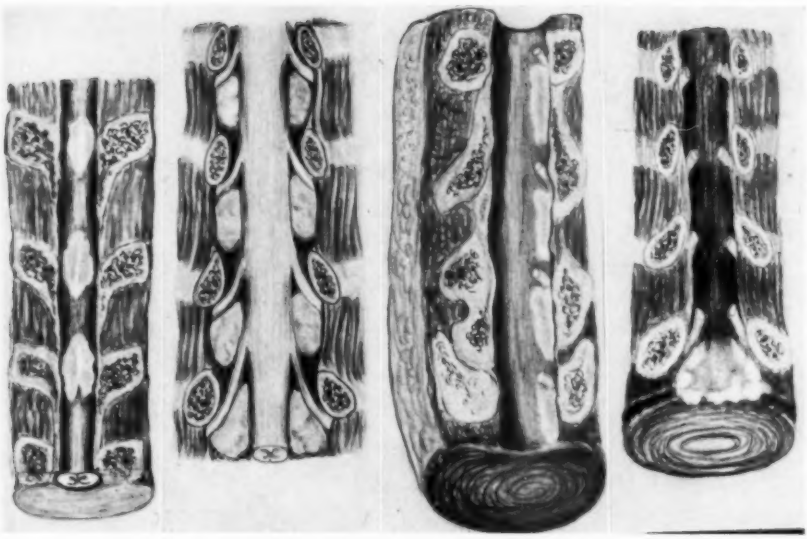



Abb. 3. Die segmentale Anordnung des reichlichen dorsalen Epiduralfettes (halbschematisch).

Abb. 4. Die Fettmassen an die Wurzelscheiden (halbschematisch).

Abb. 5. Die laterale Begrenzung des Spinalkanals mit den diese auskleidenden Fett (halbschematisch).

Abb. 6. Der Fall mit den am reichlichsten entwickelten ventralen Fettschicht, die aber nur bis zur vierten Zwischenknorpelscheibe hinaufreicht (halbschematisch).

Nachdem die Verhältnisse auf der Dorsalseite studiert worden waren, entfernte ich den Duralsack und stellte die Verteilung des Fettes um die Wurzelkanäle und im ventralen Epiduralraum fest. Der Lumbalabschnitt wurde in Anbetracht der bekannten Tatsache gewählt, dass die Knorpelscheibenbrüche am weitaus häufigsten hier ihren Sitz haben. Aus technischen Gründen musste die Sektion leider im fünften Intervertebralraum erfolgen, doch war es dank der Fixation möglich, auch von den Verhältnissen im untersten Teil des Lumbalrückens ein zufriedenstellendes Bild zu gewinnen.

Die Untersuchung ergab folgendes:

1. An der Dorsalseite des Duralsackes findet sich in allen Fällen eine reichliche Fettmenge in typisch segmentärer Lagerung (Abb. 3), und zwar sind die von den Bögen bedeckten Partien fettlos, während unter den Ligg. flava reichlich Fett vorhanden ist, das hier den Zwischenraum zwischen den Ligamenten und dem Duralsack ausfüllt. Eine prak-

tische Konsequenz dieses typischen Verhältnisses ist, dass das Risiko einer Duralläsion in diesen letzteren Partien geringer ist als in den Partien unter den Bögen.

II. Die Wurzeln sind von einer reichlichen Fettscheide umgeben (Abb. 4), die auch die laterale Begrenzung des Spinalkanals auskleidet (Abb. 5), in keinem der untersuchten Fälle aber hier einengend wirkt. Diese lateralen Fettmassen stehen mit den dorsalen Fettsegmenten in Verbindung.

III. In dem Spaltraum zwischen dem Duralsack und dem Lig. longitud. findet sich keine makroskopisch erkennbare Fettschicht. Eine Ausnahme macht das Gebiet am fünften Intervertebraldiscus. Hier findet sich in sämtlichen Fällen eine ventrale Kommunikation zwischen den lateralen Fettablagerungen, doch hat die fragliche Fettschicht bei dem vorliegenden Material nur eine geringe Mächtigkeit von etwa 1 mm. Bloss in 2 Fällen ist eine grössere Mächtigkeit registriert worden (Abb. 6), und zwar mit einer Fettschicht von bis zu 5 mm. Das reichlichere Vorkommen von Fett in dieser Gegend erklärt sich aus der mehr dorsalen Verlauf und geringeren Durchschnitt des Duralsackes in dieser ihren letzen Centimetern. Diese ventrale Fettschicht erstreckte sich aber in keinem Falle oberhalb des vierten Intervertebraldiscus, darüber ist die Ventralseite des Lumbalrückens in sämtlichen Fällen ohne makroskopische Fettschicht.

Diese anatomische Untersuchung hat somit ergeben, dass man bei der intraduralen Myelographie nur im Gebiet der fünften Intervertebralscheibe die Möglichkeit einer ventralen Fettschicht von solcher Mächtigkeit in Betracht zu ziehen braucht, dass diese ab und zu das Vorhandensein einer Hernie verschleiern kann. Das Vorkommen der lateralen Fettablagerungen im Spinalkanal bietet eine gewisse Erklärung für die Schwierigkeit der myelographischen Diagnose lateral gelegener Prolapse — doch dürften hier die anatomischen Verhältnisse des Duralsackes selbst die entscheidende Rolle spielen. Der oben mitgeteilte Fall weist auf die Möglichkeit hin, dass diese lateralen Fettansammlungen in Einzelfällen abnorme Ausmasse erreichen und den Platz im Spinalkanal so in Anspruch nehmen können, dass ein positiver intraduraler Myelographiebefund erhoben wird, ohne das ein Knorpelscheibenbruch vorliegt.

## ZUSAMMENFASSUNG

Anatomische Untersuchung von 25 fixierten Lumbalrücken inbezug auf die Verteilung des epiduralen Fettes, die von Bedeutung für die myelographische Differentialdiagnose bei Discusprolaps sein kann. Ergebnisse: 1. reichliche dorsale Fettmassen in segmentaler Anordnung, 2. laterale Auskleidung nie aber Beeinträchtigung des Spinalkanals, 3. im ventralen Epiduralraum nur in Höhe der 5:ten Zwischenknorpelscheibe eine meist schwach entwickelte, oberhalb der 4:ten keine makroskopische Fettschicht.

## SUMMARY

The author reports autopsy examination of 25 lumbal backs for the purpose of investigating the distribution of the epidural fat which may be of importance in differential diagnosis by means of myelography in the presence of prolapse of the disk. The findings at the examination were the following: (1) evidence of abundant dorsal aggregations of fat which were segmentally arranged, (2) presence of lateral coating but no involvement of the spinal canal, (3) in the ventral epidural space only in the height of the 5th intervertebral disk there was presence of a mostly poorly developed macroscopic fat layer, and superior to the 4th intervertebral disk there was absence of it.

## RÉSUMÉ

Examen anatomique de 25 colonnes lombaires fixées, pour étudier la répartition de la graisse épidurale, cette répartition pouvant jouer un rôle dans le diagnostic différentiel avec le prolapsus discal. Résultats: 1. Il existe des masses graisseuses dorsales abondantes, disposées segmentairement. 2. Il y a un revêtement latéral, mais qui n'encombre jamais le canal spinal. 3. Dans l'espace épidural ventral ce n'est qu'au niveau du 5:e disque intervertébral qu'on trouve une couche graisseuse, faiblement développée la plupart du temps, et au-dessus du 4:e disque il n'y a plus aucune couche graisseuse macroscopiquement visible.

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FROM THE FIRST MEDICAL CLINIC (HEAD: PROF. G. SÖDERBERGH) AND THE DEPARTMENT OF ROENTGENOLOGY (HEAD: MED. DR. GÖSTA RUNSTRÖM), SAHLGRENSKA SJUKHUSET, GOTHENBURG.

# CELOTHELIOMA OF THE EPICARDIUM[1]

Report of the Case

by

*C. J. Hansson* and *N. Söderström*

In a paper written in 1937, ANDOLF, BERGMARK, and GELLERSTEDT, in connection with a case of their own, provided the literature with a valuable and detailed account of what is known of the disease named celothelioma of the epicardium. There is not much that can be added to their report, and the publication of another case having much the same characteristics might therefore seem unnecessary were it not for the fact that the case to be described has certain features of diagnostic interest.

## Case Report

A man aged 51 years with no past history of serious illness began to be troubled with a mild ache in both shoulders in August 1941. He consulted a physician, who prescribed salicylic acid. The pains subsided, and he thought no more about them until December of the same year, when they became worse in connection with moderate exertion. In January 1942 he found himself suffering from increasingly severe dyspnea when working, and a couple of weeks later his face began to feel tense when he leaned forward. Not long after this he could see for himself definite swelling and a bluish tinge in his face after the slightest exertion. The discomfort was at its height in the middle of March, after which it began to recede, but he was sufficiently worried to seek medical advice, and he was admitted on Apr. 2, 1942 to the First Medical Clinic of Sahlgrenska Sjukhuset. The preliminary diagnosis was myocardial damage, possibly pericarditis.

*Physical examination* (*Apr. 2*). — A well nourished, middle-aged man presenting deep cyanosis of the face and hands. Face and neck noticeably swollen. The swelling appeared to be elastic, under a definitely thickened cutis. Veins of neck and arms were swollen and tense, even when the patient stood erect. The cyanosis and swelling became accentuated when he leaned forward, and were least in evidence when he was supine.

[1] Submitted for publication Nov. 14, 1942.

No swelling or signs of venous stasis in the lower parts of the body. The liver could not be felt. No dyspnea when he was at rest. Considerable edema of the conjunctiva was present.

The ordinary clinical examination really provided no clues likely to account for these general symptoms. The area of cardial dulness was not increased. The impulse was not distinctly palpable. There were no precordial pulsations or systolic retractions of the intercostal spaces. The rhythm was regular, and there was a weak blowing systolic murmur over the base and an accentuated second aortic sound. Blood pressure 140/80. No pathologic signs from the lungs, the abdomen, or the nervous system. No enlargement of the thyroidea. No lymph glands were to be felt. The blood picture entirely norma no pathological urine findings. Sedimentation rate 21 mm. in one hour.

*Electrocardiographic examination.* — A definitely pathologic condition was revealed, the tracings having a certain resemblance to the »$T_1$ type» seen in coronary thrombosis. (Fig. 1.)

*Roentgen examination (Apr. 7).* — The superior mediastinum was slightly increased, but no gland shadows were visualized. No signs of aortic aneurysm. The contrast meal was swallowed without difficulty. No dislocation of the oesophagus. No changes visible in the pulmonary parenchyma. (Fig. 2.)

The disease had a monotonous and uneventful course. The patient was constantly in varying degrees of fever, with high evening, and low — subnormal — morning temperatures. When recumbent he was practically symptom-free, except for occasional pains of the radicular type around the upper part of the thorax. On account of these pains a second neurologic examination, and roentgen examination of the spine, were made. The findings were negative. When he was put on salicylic acid the pains disappeared and the variations in temperature were not so great. Occasionally there were signs of a considerable enlargement of the liver, but this only lasted a few days at a time and then subsided again. Seven control electrocardiograms showed practically the same picture as before. Electrocardiograms and roentgenograms taken with the patient on his side in various positions showed the pictures normally seen with such changes of position. The sedimentation rate varied between 20 and 62 mm. in an hour, and exhibited no tendency toward either a decrease or an increase.

The blood also remained consistently normal, apart from a mild tendency toward anemia at the beginning of the hospital stay. This disappeared later on without any special treatment.

Control roentgenograms of the mediastinum taken on Apr. 25, May 20, June 5, and July 1 revealed the same condition as before.

*Venographic examination (July 3).* — Fifty per cent perabrodil was first injected into superficial veins in both cubital fossae. On the right side the contrast medium was seen to be proceeding upwards through the basilic and then through the axillary vein. At the point where the axillary vein became the subclavian vein, and on a level with the clavicle, a well defined obstruction in the vein was visualized. Numerous collaterals, most of them on the medial aspect, were well filled with contrast. An intercostal vein on the right side was filled, and the passage of the contrast fluid could be followed up through the azygos vein approximately as far as to the point of confluence of this vein with the superior vena cava. On the left side the contrast medium was passing upwards through the cephalic vein and continued for a short distance along the axillary vein. Here also an obstruction was visualized in the vein on a level with the clavicle. The upper segment of the basilic vein was filled in a retrograde direction.

To sum up, the axillary vein was blocked bilaterally at points approximately on a level with the clavicle. The downward extent of this obstruction into the superior vena cava could not be determined, but the fact that the azygos vein was filled with contrast

Fig. 1.

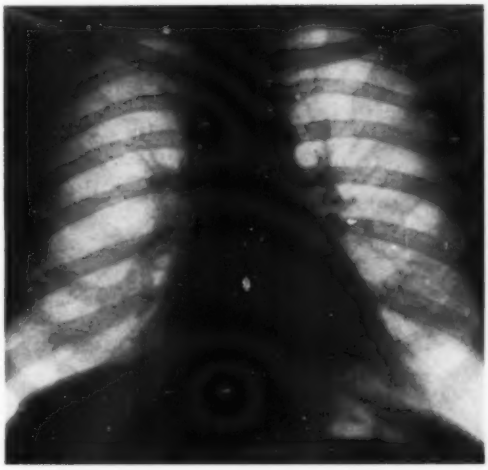

Fig. 2.

indicated that it did not reach further down than to the point where the latter vein emptied into the vena cava. (Fig. 3.)

Unfortunately, this unexpected and interesting roentgen finding could not lead to a more detailed investigation, because the patients' condition, which had been gradually deteriorating ever since his admission, was by that time such that every attempt to move him from the supine position brought on severe attacks of dyspnea and cyanosis. During one of these attacks he expired on July 28, 1942.

*Autopsy* (*Extract from the examination made by Dr.* O. FORSELIUS). — The entire pericardium was adherent to the heart. At the back, and along the left border, the adhesions were fibrous, and in places stringy. At the apex, on the anterior wall of the right ventricle, along the border of the right ventricle, and in the posterior wall of the right auricle, the adhesions were made up of a more than 1 cm. thick layer of yellowish tumourous tissue of varying consistency; in some parts it was hard, and in others somewhat crumbly. This tissue was encroaching upon the cardiac muscle, and penetrated to the endocardium. In the pulmonary artery, not far from its commencement, a fairly large tumour was loosely attached to the wall of the vessel and to the valves, but did not entirely occlude the lumen. The neoplastic tissue was interwoven with the pericardium both toward the front of the heart and on the right side, forming small nodular tumourous vegetations of about $^1/_2$ cm. in height on the anterior aspect of the pericardium. The tumour had grown into the right portion of the anterior mediastinum and extended as far up as the root of the neck, as a stalk of pathologic tissue of 2—3 fingers' thickness, in which the superior vena cava and the hilus of the right lung were embedded. A hard thrombotic mass, the cut surface of which was pale grey in colour, was firmly attached to the wall of the subclavian vein. In the right internal jugular vein there was a fresh blackish-red thrombus. A luxuriant tumour vegetation was observed in the hilus of the right lung, but there was no encroachment upon the pulmonary tissues. The tumour had grown downwards from the apex of the heart, penetrated the diaphragm, and joined up with a growth the size of a mandarine on the parenchyma of the liver. The

size of the heart was normal, and the valves showed nothing pathologic, except for the above-mentioned change in the pulmonary artery. The heart muscle was somewhat pale. Nothing remarkable in the other organs.

*Microscopic examination.* — The different parts of the tumour showed fairly homogeneous histological structure. It was composed in the main of polyhedral cells arranged in rather coarse cord-like structures; when the cells occurred in isolated examples, they were round. The cell bodies were fairly large and the nuclei smallish and pyknotic. In places the arrangement of the cords resembled stratified epithelium, this similarity being heightened by the fact that some of the cords showed degenerative changes not unlike cornification. Many of the cords contained rounded or elongated vacuoles, the outer cells then resembling a pellicle. There were abundant signs of infiltration into the muscular tissue and the pericardium. The tumour was seen to be infiltrating into the endocardium of the pulmonary valve, and into the intima, but not into the outer layer of the vessel wall. There was no direct connection between this latter vegetation and the others. Diagnosis: Malignant endothelioma.

## Discussion

The following significant factors had to be taken into consideration for the differential diagnosis.

1. The gradual onset of stasis in the blood vessels concomitant to the superior vena cava, without any signs of respiratory obstruction. This could be described in a general way as the syndrome of a mediastinal tumour.

2. Pains of the anginal type in the thorax, and an electrocardiographic finding suggestive of infarction of the $T_1$ type; in other words, a coronary syndrome.

3. A roentgen picture of the mediastinum showing such slight deviations from the normal that it was doubtful whether it could be considered pathologic.

The roentgenographic evidence practically ruled out the likelihood of an extracardial mediastinal tumour of the lymphosarcoma, STERNBERG, or aneurysm types, since such growths, before they could cause such a high degree of stasis through external pressure on the vessel walls, would be expected to yield a roentgen picture of a tumour of considerable dimensions.

An inflammatory, infective mediastinitis could have accounted for the stasis, but the roentgenogram did not resemble the picture usually seen in mediastinal infections. No pulmonary lesions were visualized, and these would undoubtedly have been present if a mediastinitis producing such definite symptoms had been the cause.

The associated coronary syndrome, and the fact that the disease gave all the signs of a pure vasculatory disturbance, made it probable instead that the root of the trouble lay in some exclusively cardiac affection.

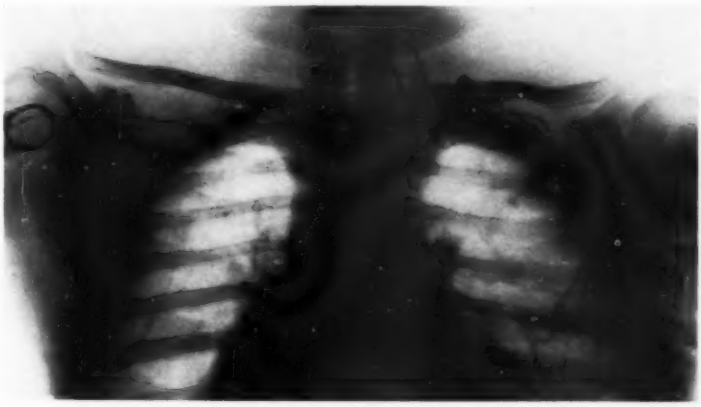

Fig. 3.

The possibilities for explaining the symptoms along these lines were actually very few. It was conceivable that a thrombotic process was occluding the superior vena cava from within, and that coronary thrombosis had arisen as a result. Not even this assumption, however, provided any satisfactory points of contact between the two main syndromes. In fact, the only type of disease capable of bringing all the symptoms into line with a single diagnosis was some form of chronic productive pericarditis, which would constrict the superior vena cava, and which yields an electrocardiogram reminiscent of cardiac infarction and n ot uncommon in pericarditic diseases.

As is well known, the commonest form of chronic pericarditis based on an inflammatory process usually produces signs of stasis in the region of the inferior vena cava, particularly in the liver. In our patient, there was only occasional stasis in the liver, and this was by no means a dominant feature of the case. One of the authors of this communication, who was present at the postmortem examination on the ANDOLF-BERGMARK-GELLERSTEDT case, was strongly of the opinion that this type of »armoured» heart, which, according to most of the descriptions in the literature, originates from tumours and produces the most pronounced changes just in the region of the superior vena cava, was the most likely cause of the condition in our own case.

Through the courtesy of Professor LAURELL, we are reproducing a roentgenogram of the Uppsala case. It will be immediately apparent from this picture that the case differed from ours in one important particular, in that there is evidence here of a large, wide-spread mediastinal tumour. (Fig. 4.)

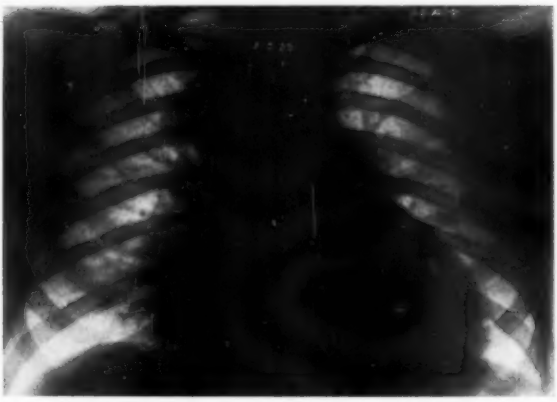

Fig. 4.

To anyone who has seen the postmortem evidence in a case of this kind, however, this difference is not of primary importance. Concurrently with the expansive growth of large, isolated neoplastic foci, there also occurs in celothelioma of the epicardium — as the most typical method of propagation — an infiltration of small nodules into the pericardium and the myocardium and along the large branches of the blood vessels. This process is not easily disclosed by roentgenography. Both methods of spreading have been observed in almost all the cases reported, but nodular infiltration, which was the dominant feature in our case, is in all probability the most characteristic.

We finally came to the conclusion that the most probable diagnosis was a tumour of the above-mentioned type in the pericardium. The chronically progressive nature of the disease gave a certain support to this theory. The phlebographic finding which, with its signs of bilateral obturating lesions extending far down into the branches of the superior vena cava, had at first been so unexpected, was a further piece of evidence in favour of the correctness of our diagnosis.

Further confirmation might have been obtained by roentgen therapy. The Uppsala patient received radiation treatment which proved temporarily effective, the tumour responding quickly to a dose of about 1,000 r., given in doses of 250 r. at each session, with a filter of $^1/_2$ Cu. and 1 Al. This treatment was renewed with good results at 2—3 month intervals. In this case, however, the early appearance of unmistakeable signs of a mediastinal tumour, and roentgenographic evidence of bone metastasis, were two advantages which were not present in our case.

Our patient was given radiation therapy at an early stage, but the

doses were too small (100 r. at each of 3 sessions with a filtration of 0.5 mm. Cu. and 1 mm. Al.) The effect was problematical, and in any case it could not be verified by ojective means. When our theory as to a tumour had begun to take definite shape the patient was unfortunately already so poorly that there was no time to continue the roentgen treatment.

This case is being reported chiefly to act as a complement to the case described by ANDOLF, BERGMARK, and GELLERSTEDT, and readers wishing to study earlier literature on the subject are therefore referred to the publication mentioned at the beginning of our paper.

## SUMMARY

There is described in this paper a case of celothelioma of the epicardium, the features of particular interest being the absence of roentgenographic signs of mediastinal tumour, and electrocardiographic changes of the coronary type. From the differential diagnostic point of view, a comparison is made with a similar case reported by ANDOLF, BERGMARK and GELLERSTEDT.

## ZUSAMMENFASSUNG

In der vorliegenden Arbeit wird über einen Fall von Celotheliom des Epikards berichtet. Von besonderem Interesse ist das Fehlen röntgenographischer Anzeichen für einen Mediastinaltumor und das Vorliegen elektrokardiographischer Veränderungen von Koronartyp. In differentialdiagnostischer Hinsicht wird ein Vergleich mit einem ähnlichen Fall angestellt, welcher von ANDOLF, BERGMARK und GELLERSTEDT mitgeteilt worden war.

## RÉSUMÉ

Ce travail apporte la description d'un cas d'endothéliome de l'épicarde. Fait particulièrement intéressant: les signes radiographiques d'une tumeur médiastinale manquaient, comme faisaient défaut aussi les modifications électrocardiographiques du type coronarien. Au point de vue du diagnostic différentiel l'auteur établit une comparaison avec le cas similaire rapporté par ANDOLF, BERGMARK et GELLERSTEDT.

## LITERATURE

ANDOLF, N., BERGMARK, G., and GELLERSTEDT, N.: Upsala läkaref. förh. 42: 363, 1937.

# EXPERIMENTS WITH MAMMALIAN SARCOMA EXTRACTS IN REGARD TO CELL-FREE TRANSMISSION AND INDUCED TUMOR IMMUNITY[1]

by Carl Krebs, Johannes Harbo and Oskar Thordarson

Acta Radiologica Supplementum XLIV

A Summary

by

*Carl Krebs*

with a brief mention of the tumor studied, which is described in Supplementum X by Carl Krebs, H. C. Rask-Nielsen & Aage Wagner: The Origin of Lymphosarcomatosis and its Relation to other Forms of Leukosis in white Mice.

Supplement XLIV of the Acta Radiologica continues the record of the series of studies made in the last twelve years at the Radium Centre in Aarhus, of the mouse leukosis described in 1930, in Supplement X, by Krebs, Rask-Nielsen and Wagner. In the last eight years our efforts have continuously been directed towards finding out whether this tumor might possibly be due to a virus.

Many forms of cancer immediately give one the impression of a virus disease, many others suggest infection as the causative factor, and of others again the appearance and manner of development are such that one cannot but compare them to those forms of the disease which we know so well from tar cancer in mice. That such a study, such a search for a virus, may perhaps lead to great disappointment is something for which one must be prepared. From Jensen's work with beet-cancer tumors caused by a bacterium we know that this bacterium disappears shortly after the development of the tumor, and something similar we know from Fibiger's work with spiroptera cancer, where the roundworm which causes the disease has often disappeared by the time the latter is discovered. But of both these diseases we also know that they may persist and be transmitted even if the agent provoking them can no longer be found. In this negative result, in the fact that nothing is found, there is

[1] Submitted for publication, Oct. 9, 1942.

nothing which with certainty tells us that the disease is not determined by a virus.

In the following I shall tell about our numerous experiments and also briefly describe the technic employed. For further particulars of the latter I must refer those interested to the supplement volume (Supplementum XLIV), where it is explained very fully.

The tumor with which we have worked is the transmissible mouse leukosis described in 1930 by KREBS, RASK-NIELSEN and WAGNER, — a round-cell tumor, probably of the lymphosarcomatous type. It has later been described by several of the assistants at the Radium Centre, THRANE, KAALUND-JØRGENSEN, RASK-NIELSEN and BICHEL, each of whom has come to a different conclusion as to its proper designation. BICHEL, who has been the last to study it, and who succeeded in cultivating it in vitro, believes that it is a myelomatous, or possibly a stem cell tumor.

Tumors of this type have been known for many years. Already in 1911, the Norwegian investigator, HAALAND, in a paper published in the Report of the Imperial Cancer Research Fund, described a number of affections in mice, arisen from the lymphatic tissue. Some workers have at various periods in their mouse kennels found considerable numbers of mice with leukemic changes; thus, TYZZER found not less than 10 cases of »lymphomata» among 70 tumor-bearing mice.

In 1929, there suddenly began to appear in our mouse stock a number of cases of spontaneous lymphosarcoma, for which we at first were absolutely unable to find any explanation. The mice with which we had been working since 1923 were not of pure strain, but had all been purchased from the same dealer. We therefore made a careful search of the dissection records for this period, which resulted in the very interesting finding that of 10,500 non-irradiated mice 3 (= 0.29 per thousand), and of 5,500 irradiated 19 (= 3.5 per thousand), had presented leukemic changes of the organs. These changes had thus been over ten times as frequent in mice that for some reason or other had previously been subjected to roentgen — for instance in experiments for determination of the lethal or the epilatory dose — as in the animals that had not been thus exposed; a fact which must, of course, give cause for meditation. Previous workers with these tumors had only in very few instances succeeded in transmitting them from one animal to another, but precisely at that time our laboratory was engaged in studies of the effect of general irradiation with roentgen on the organism, — a very fortunate circumstance, as we thereby succeeded in transmitting the tumor in several successive passages, something which would otherwise hardly have been the case. Since then we have been working only with pure strains, and the tumor is now readily transmitted from animal to animal without previous irradia-

tion with roentgen. The strain which we use at present is the so-called »Bagg A».

It has been discussed whether the disease found in the mice was a tumor or a leukosis. When it is transmitted from one animal to another. it oftenest takes the form of a solitary tumor, which grows, however, without any capsule and frequently invades the pleura and abdomen, where it produces ascites fluid. But often, too, — and this was the case especially in the strongly irradiated mice to which we formerly transmitted it, — it takes the form of a generalised disease, producing, besides an isolated tumor, either STERNBERG's leukosarcoma, lymphadenosis (leukemic or aleukemic) or, as in one case, an isolated lymphosarcoma of the liver.

I mentioned above the occurrence of ascites fluid when the tumor invades the abdomen. Ascites fluid can easily be produced experimentally. This is a great help. In the first place, the fluid is very malignant, in the second place, the experimental production enables one to determine at will the quantity to be transmitted, because the fluid can be diluted and the malignant cells counted just as easily and in the same manner as one counts blood corpuscles. To produce ascites fluid, one simply, by means of a cannula, injects a small quantity of tumor pulp — about 0.05 ccm. — into the abdomen of a mouse. After ten to twelve days the practised laboratory assistant will be able to tell, simply by palpation, whether there is ascites in the abdomen. The first passage gives only a very small quantity of fluid, though; about 0.3 to 0.5 ccm. If this is diluted and a small quantity of the dilution — about 0.1 ccm. — injected into a new batch of mice, ascites fluid will form in these in the course of seven or eight days (thus more rapidly than in the first passage), and this time perhaps as much as 1 to 2 ccm. By continuing thus for two-three passages or more, one may succeed in getting as much as 4 ccm. of ascites fluid from a single mouse, — a very large quantity when it is remembered that it often represents more than a fourth or a fifth of the animal's weight.

To determine whether a disease is due to a virus or not, it is necessary to filtrate extracts of the tissue in which it has its development, or in some way or other to destroy the cells and then try whether the substance left over is still capable of producing the disease. For, as a virus is ultra-visible, it can of course only be recognised by its effect. A number of different procedures may be used for this purpose of finding out whether a disease is virus-induced, all of which we have tried on a considerable animal material.

1) We have tried to produce cell-free extracts. This is the simplest and most natural method; only, one must make sure that the extracts are really cell-free.

2) We have tried the same procedure as used in producing adsorbates. It has been found, especially in the work with foot-and-mouth disease, that a virus can be bound to aluminum hydroxide, carbon or diatomaceous earth, and that adsorbates from subinfectious virus dilutions are capable of acting pathogenetically.

3) We have used tumor cell-containing material that had been exposed to very strong irradiation with roentgen.

4) We have tried the effect of adding brain tissue or brain extracts to cell-free tumor material.

5) We have used autolysates of tumor tissue and

6) dried and finely triturated tumor tissue.

### 1) The cell-free Extracts

As the cell-free extracts play the most important rôle, by far, in these experiments, I shall briefly explain the technic used in their production.

The material was as a rule either cell-free ascites fluid or crushed tumor tissue. When ascites fluid was used, the cells were first isolated from the fluid by centrifuging, then ground finely with a little powdered pyrex glass or quartz sand moistened with the extraction medium used. When it was wished to prevent oxygenation of the latter, cystein or ascorbic acid was added to it. In some instances the grinding was done in a glass chamber filled with nitrogen. When it was wished to make extract of ascites fluid, the ground cells were added to the fluid from which they had previously been removed.

After the tumor- or ascites cells had been ground in the manner described, they were centrifuged and filtered, or else only centrifuged, in order to make the extracts absolutely cell-free. For filtering, we mostly used Elford's Gradocol filter (made in England); the width of the pores was measured to about 0.9 $\mu$. Besides, we used, especially in the beginning, Berkefeld filter and Seitz E—K Schichten. Space does not permit a detailed description here of the technic of filtration, but it may be noted that no result can be hoped for if the concentration of the filter extract is higher than 5 per cent. A concentration of 2 per cent gives a better result, as shown by experiments with swine-fever. Immediately after every experiment, all the filters were tested with a fowl cholera culture and following inoculation into mice.

The extracts can also be made cell-free by centrifuging alone, but this requires a special technic. They must be centrifuged three or four times, each time for about 15 minutes, and at the first aspiration special care must be taken to avoid the layers at the surface and along the edge, at the last two or three to avoid the precipitate at the bottom. The centrifuges we used were an Ecco Ultimo II with a centrifugal field of

20,000 times the gravity and a SVEDBERG's with centrifugal field 35,000 times the gravity. Before the centrifuged, cell-free fluid is used for an experiment, each drop used must be examined under the microscope.

Our first experiments with transmission of the disease by means of cell-free extracts comprised 1,006 mice, and in 12 cases growths were produced, but in 3 of them so long after the inoculation that we could not be sure of any causal relation between the latter and the tumor which eventually developed. In the 9 other animals the growths appeared after injection of a 5 per cent tumor extract that had been filtered through a Gradocol filter which, as always, at the end of the experiment was tested with a fowl cholera culture. In these last cases it would thus seem that cell-free transmission had actually taken place; still, two circumstances make it probable that at some point or other an accident had happened or a fault been committed. The first is that all the successful transmissions occurred in the same experiment, the second that we, in spite of numerous attempts, never succeeded in repeating it. Consequently, we cannot claim it as a proof.

In 1931, KREBS and SCHMIT-JENSEN showed by experiments with intense roentgenisation of cowpox- and foot-and-mouth disease viruses that not only was the irradiation incapable of inactivating these, but it seemingly increased their virulence, inasmuch as the disease apparently assumed a more violent character after such irradiation. We emitted at that time the hypothesis that exposure to roentgen might have an activating effect on a virus. Later it has been shown by KAUSCHE and STUBBE that the same applies to the virus of tobacco-mosaic disease. We therefore irradiated cell-free tumor extracts with doses of from 12,000 to 20,000 r before injecting them into a number of mice, and in one case observed growth from such an inoculation.

Eighty-seven experiments, in all, were made, with cell-free extracts, into which entered a total of 1,205 mice.

### 2) The Adsorbates

Adsorbates are generally used when it is wished for certain purposes (i. a. immunisation) to localise the effect of a virus. On introduction into the organism the adsorption compounds usually prove pathogenic, but sometimes less so than the free virus. SCHMIT-JENSEN, SCHMIDT & HANSEN found that the infectiosity became very much reduced when adsorbates of fresh foot-and-mouth disease virus on aluminum hydroxide were injected subcutaneously. Later it has been shown by HARBO that when the adsorbate contains phosphate ions at pH about 7.6 no reduction of the infectiosity occurs.

The use of adsorption for the demonstration of viruses might seem

irrational, but in some experiments G. PYL could in this manner (adsorption on charcoal) demonstrate small amounts of the virus of foot-and-mouth disease in subinfectious dilutions by accumulation of the virus from the solutions and following inoculation of the adsorption compound into guinea-pigs. In these cases the adsorbed virus particles act pathogenically either in the adsorbed state or after elution has been caused by the ions of the tissue.

Besides aluminum hydroxide, we also used as adsorbing substances carbon, diatomaceous earth and mixtures of these; but in no instance did the experiments give results that might indicate the presence of a virus. In using diatomaceous earth we also had in mind the significance of a *locus minoris resistentiæ*.

In all, 30 experiments were made, with 156 mice.

### 3) Experiments with irradiated, tumor-cell-containing Material

If we compare the roentgen doses needed to kill tumor tissue — or rather to prevent it from producing growth when transplanted — with those required for complete inactivation of a virus, we see that the last are under all conditions much larger than the former, at least with the radiation we generally use, produced by a tension of between 100 and 200 kilovolts. There thus seems to be a possibility of distinguishing between virus-determined and not virus-determined tumors by irradiation with roentgen. Most investigators have found a so-called lethal dose for tumor tissue, of about 3,500 r., and KAALUND-JØRGENSEN found this to be the lethal dose also for the tumor used in these experiments; but as it had formerly been so difficult to transmit, we thought it necessary once more to try to determine the dose needed to kill it.

We succeeded in obtaining growth in 6 cases with doses of at least 4,260 r and 6,860 r. Tissue irradiated with larger doses did not produce growth. There are no reported cases of transmission having been obtained of tumors irradiated in vitro with doses as large as 7,000 r or thereabouts, but as we think of the lesion-curve for tumor cells as having an asymptotic course towards the zero ordinate, we must reckon with the successful transmissions being in our cases occasioned by surviving cells. Thus it is not warrantable from the lethal doses found in these experiments of ours to conclude to the presence of a virus. A total of 302 mice entered into these experiments.

### 4 — 5 — 6

The experiments with brain tissue, autolysed tumor material and dried and finely divided tumor tissue all gave negative results. The limits set for this summary do not permit a lengthy exposition of the reasons

which prompted us to try these procedures, but it may briefly be said that it was partly KAALUND-JØRGENSEN's successful experiments with transmission of apparently cell-free brain tissue which led us to the experiments of that kind, partly experiences with Rous's sarcoma which led us to try autolysed tissue and the transmissibility of dried tissue. It will be remembered that when a request for Rous's sarcoma was made to America before the present war, the sending was always received in an ordinary envelope.

If we would draw any conclusion from the results of these many experiments, amounting with experimental animals and controls to over 5,000 in all, it must be that there does not seem to be any sure signs of the tumor — or leukosis — with which we worked being due to a virus. True, there are a few, scattered transmission results — 15 mice in all — which we are unable to explain. They may have been due to technical errors; on the other hand it is possible that in these few instances all the conditions necessary for producing such a disease may have been present. As we know, leukemia and diseases of that type are not among the most frequent. We do not know yet what causes them, or what interplay of factors is required; perhaps the simultaneous presence of those factors is as rare in the case of humans as in the case of animals. But however it may be, and though we cannot explain it, it is of course possible that in these few cases where the transmission succeeded all those factors have been present and have interacted to produce the result.

### Studies of the resistance-increasing Effect of the cell-free Tumor Material

Our object with these experiments was to try whether the mice which in various ways had been inoculated with cell-free extracts, adsorbates, ascites fluid etc., and in which this pretreatment had not caused tumor growth or leukosis, were more or less susceptible to a subsequent abdominal inoculation with tumor-cell containing ascites fluid than mice which had not been thus pre-treated; the assumption being that when two qualitatively uniform batches of animals are given injections of exactly the same quantities of ascites fluid, the relative number in which the injection produces growth will be the same in both.

The results of these experiments may be divided into two groups. In one of them, in which the previously treated animals had been inoculated with adsorbates of aluminum hydroxide, carbon or diatomaceous earth, there was no difference in the manner in which they and the non-treated controls reacted to the abdominal injection of the diluted ascites fluid; the proportion of »takes» would be higher now among the former,

now among the latter. In the other, in which the previously treated animals had been inoculated with cell-free extracts, — or with the residual solution of such, from which adsorption had been attempted, — the proportion of cases in which the injection of ascites fluid produced growth was, on the other hand, so very much smaller than among the controls that we could not but hold it as probable that the pretreatment with cell-free material had induced an increased resistance.

From the individual experiments it is not possible to say with certainty whether the difference is an actual one, for only in one of them was it greater than 3 times the standard error. But when we submit all the ratios *difference/corresponding standard error* to a further statistical analysis, we find that their sum deviates 5.2 times the standard error from the value estimated under the supposition that all the differences found were fortuitous. As a deviation of that magnitude can hardly be fortuitous, we must conclude that it is the expression for an actual increased resistance to the tumor growth in the mice inoculated with the cell-free extracts.

Full reviews of the literature will be found in Supplementa X and XLIV.

## SUMMARY

The author gives a brief survey of the contents of Supplementum XLIV to Acta Radiologica.

## ZUSAMMENFASSUNG

Verf. gibt eine kurze Übersicht vom Inhalt des Supplementum XLIV zu Acta Radiologica.

## RÉSUMÉ

L'auteur donne un bref sommaire du contenu de Supplementum XLIV des Acta Radiologica.

FROM THE ROENTGEN DEPARTMENT OF SERAFIMERLASARETTET, STOCKHOLM, SWEDEN
(PHYSICIAN-IN-CHIEF: DR. ERIK LYSHOLM)

# ON THE DIAGNOSIS OF RUPTURE OF THE URINARY BLADDER[1]

by

*Olov Fr. Holm*

Rupture of the bladder is a relatively unusual injury, which has received very little attention from a roentgenologic viewpoint. It is not mentioned in current textbooks on roentgen diagnosis.

With regard to incidence, it may be mentioned that NAUMANN in 1912 collected three cases among 20,000 admissions and CAMPBELL in 1929 published 55 cases gathered over a period of fourteen and a half years, corresponding to one case in every 5,500 surgical admissions. REXFORD published 1939 11 cases from about 137,000 admissions. We have seen three cases at the Roentgen Department of Serafimerlasarettet, two of them during the summer of 1942.

## Case Histories

*Case 1.* The patient, a fifty-year old woman, was treated at the Surgical Department of this hospital under the diagnosis of fracture of the pelvis, vertebral fractures, fracture of the right lower leg and fat embolism. She had fallen from a street car and landed underneath. She was immediately taken to Serafimerlasarettet. On admission she was acutely ill and complained of intense pain in the abdomen and pelvic region. Immediate catheterization of the urinary bladder yielded blood only. Roentgen examination revealed fractures through the pelvic ring, running on the right side through the pubic bone and the ischium. On cystography, the urinary bladder was seen to be dislocated to the left and the contrast fluid was observed to pass into an irregular cavity on the left (fig. 1). The patient died on the third day and obduction was done. Postmortem examination revealed the urinary bladder to be empty, with a rupture about two and a half centimeters in diameter, leading into a tangerine-sized cavity, in its super-posterior portion.

*Case 2.* The patient, a man of forty-three years, was run over by an automobile. On admission he was confused and under the influence of alcohol. Roentgenograms made immediately showed a small gas bubble directly under the right dome of the diaphragm in the lateral position (fig. 2), as well as free fluid in the abdomen.

On cystography the patient experienced severe pain when the fluid was injected (20 c. of intron diluted with sterile water to make up 100 cc.), and the fluid did not

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Fig. 1.

Fig. 1. Case 1. Fractures through the pelvic ring. The urinary bladder, which is filled with opaque medium, is dislocated to the left and the medium is seen passing out into an irregular cavity with unclear contours in the perivesical space.

Fig. 2. Case 2. A small bubble of gas under the right dome of the diaphragm in the lateral position.

Fig. 3. Case 2. Large, dilated urinary bladder, sharply delineated inferiorly and laterally and diffusely delineated superiorly.

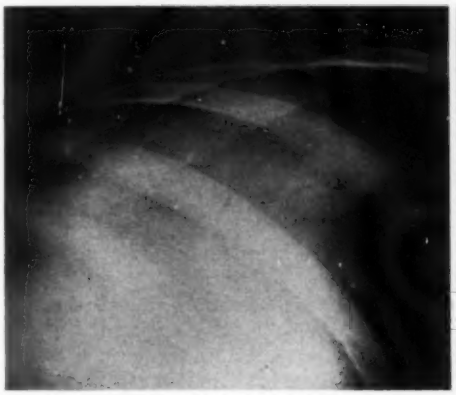

Fig. 2.

Fig. 3.

regurgitate, which was direct evidence of the presence of a rupture. It is seen from the cystogram (fig. 3) that the urinary bladder was clearly delineated inferiorly and laterally, but diffusely outlined superiorly. The picture is somewhat ambiguous, but may be considered to support the diagnosis of rupture of the bladder. Operation revealed a seven-centimeter long rupture in the posterior portion of the peritoneum-covered part of the urinary bladder. Further findings comprised a rupture one centimeter in diameter in the small intestine and a number of minor lesions. The patient died on the ninth day.

*Case 3.* The patient, a fifty-seven-year old man, fell forward and landed heavily on the abdomen when under the influence of alcohol. He was admitted to the hospital about four hours after the accident. His condition was not especially poor. The abdomen was soft, with slight tenderness inferiorly and to the right. The urine was grossly bloody.

Fig. 4.

Fig. 5.

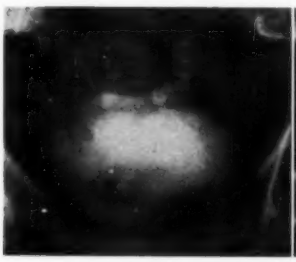

Fig. 6.

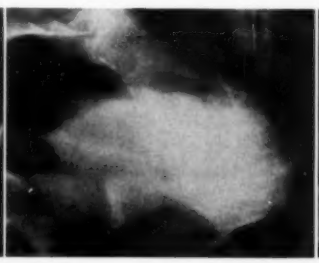

Fig. 7.

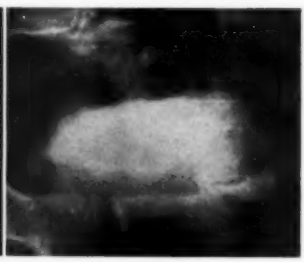

Fig. 8.

Fig. 4. Case 3. Lamellar atelectasis basally in the lungs, manifesting a severe pathologic process in the abdominal cavity.

Fig. 5. Case 3. A general roentgenogram of the true pelvis showing the clearly outlined urinary bladder.

Fig. 6. Case 3. Filled with contrast fluid, the urinary bladder appears to be of normal size and well outlined. Note the irregular deposit of medium which is projected into the centre of the bladder and is visible due to hard exposure of the medium.

Fig. 7. Case 3. On the oblique picture can be seen an irregular bulge of medium directed upward and to the right. This is due to the fact that the contrast fluid is on its way out through the rupture.

Fig. 8. Case 3. Cf. fig. 7. After only about ten minutes, distinct fogginess developed so that the outline of the site of the rupture became more diffuse.

General roentgenograms of the abdomen were made immediately, but revealed nothing definitely pathologic. The pain gradually decreased and the patient slept most of the night. The next morning pain developed rather suddenly, and the abdomen became swollen, with diffuse tenderness. Renewed roentgen examination showed free fluid in the abdomen as well as lamellar atelectasis in the basal portions of both lungs, evidencing a severe pathologic process in the abdomen (fig. 4). General views of the true pelvis revealed an apparently normal-sized urinary bladder clearly delimited from its surroundings (fig. 5). In addition to an evenly outlined urinary bladder, frontal cysto-

grams showed an irregular deposit of contrast medium projected into the middle of the bladder shadow and visible due to hard exposure of the opaque fluid. This would not have been visualized with denser contrast fluid or softer exposure (fig. 6). An irregular, spigot-like bulge of the fluid with ragged contours could be seen upward and to the right in the oblique picture (fig. 7). Laparotomy was done immediately on the diagnosis, rupture of the bladder, exposing an abundance of bloody fluid. There was an intraperitoneal rupture admitting three fingers in the superior right part of the urinary bladder, corresponding to the above-mentioned spigot-like bulge. The convalescence was uneventful and the patient was discharged in good condition after twenty days.

A full bladder is the most important etiologic factor in the occurrence of a rupture of the bladder. When the bladder is empty it lies down in the true pelvis and is incapable of rupturing; it can only be perforated by fracture fragments or foreign bodies. The more distended the bladder is, the less severe is the trauma required to rupture it. PELKONEN stated that with maximal distention, the subject turning over and lying on his stomach in his sleep is enough to produce a rupture, and with intoxicated patients he considered that the possibility of trauma cannot be excluded, even if none can be demonstrated in the case history. These cases approach the field of the so-called spontaneous ruptures which, however, do not arise without some pathologic process in the bladder wall, such as syphilis, tuberculosis, lipomatosis, etc. The great importance of distention is connected with the fact that the contents are not compressible and that the shape of the distended bladder approaches that of a sphere, whereby any trauma serving to change that shape greatly increases the tension in the bladder wall.

Alcoholic abuse plays a major part in the occurrence of bladder ruptures. In the first place, alcohol has an anesthetic effect, so that the subject does not so quickly notice a need to urinate, in the second place it has a diuretic action, which raises the tension of the bladder, in the third place it relaxes the abdominal muscles, whereby the bladder's protection is decreased, and in the fourth place it puts the subject into a mental state in which he is more exposed to traumas of various kinds than normally. Of PELKONEN's cases, 43.75 per cent were under the influence of alcohol, while REXFORD's figures were seven out of ten. STUBERNRAUCH gave the figure 35 per cent and STEVENS and DELZELL more than 50 per cent.

Rupture of the bladder usually occurs as the result of more or less pronounced violence to the inferior part of the abdomen and pelvis. It may be combined with fracture of the pelvis or it may develop with no accompanying fractures. BARTELS in 1878 found 65 cases of rupture of the bladder in 169 cases of pelvic fracture. STEVENS and DELZELL in 1937 reported that rupture of the bladder was present in 15 per cent of 166 cases of pelvic fracture. I have reviewed 100 cases treated at the Surgical Department of Serafimerlasarettet for pelvic fracture, choosing

only those with fractures through the pelvic ring running in the region of the symphysis. Among the cases thus selected I found only three cases of rupture of the bladder. Cystography was not done in one of these cases (1923). Operation revealed a thumbnail-sized intraperitoneal rupture. The patient was discharged as cured. In the second case (1925), attempts at cystography were made by injecting 75 cc. of 5 per cent sterile potassium bromide. The patient experienced intense pain in connection with this process, and consequently no roentgen examination was made. Operation disclosed two long extraperitoneal ruptures. This patient also was discharged healthy. The third case with fractures of the pelvis is described as Case 1 herein.

The figures cited by BARTEL and by STEVENS and DELZELL appear unexpectedly high. In the case of BARTEL's figure, it must be assumed that a large number of pelvic fractures were overlooked, since they belong to the pre-roentgen period. It is more difficult, however, to explain the discrepancy between STEVEN's and DELZELL's 15 per cent and my 3 per cent.

The ruptures which appear without fractures of the pelvis are practically all intraperitoneal. Ruptures combined with pelvic fractures are extraperitoneal in two-thirds of the cases and intraperitoneal in one-third (PELKONEN, BARTELS and others). These figures correspond fully with my material.

The clinical signs in rupture of the bladder are characterized by more or less pronounced urinary retention in a patient who has been exposed to a trauma to the bladder region. As a rule the patients are suffering from shock. In the case of people strongly under the influence of alcohol, it sometimes happens that no history of trauma can be ascertained. The urine is generally grossly bloody. Catheterization yields either small quantities of bloody urine or large quantities of fluid (as much as seven liters has been mentioned), depending on whether the point of the catheter remains in the bladder or passes through the rupture into the abdominal. Fluid injected through the catheter generally does not flow back.

Cystoscopy entails a certain risk of infection. STEVENS and DELZELL were of the opinion that the diagnostic value of cystoscopy is greater than the danger involved, and that the risk is insignificant if operation follows immediately afterward. They made cystoscopic examinations of 13 cases of rupture of the bladder with positive findings in 11. Most other workers, on the other hand, regard cystoscopy as more or less useless, since in rupture the urinary bladder can generally not be sufficiently distended and since hemorrhage obstructs the view.

The most important diagnostic method in rupture of the urinary bladder is undoubtedly roentgen examination.

The first thing to do in cases of suspected rupture of the bladder is to take general roentgenograms of the abdomen and investigate for free fluid. However, one should not fail also to look for free gas, since one is dealing with patients who, like the one in my case No. 2 above, have suffered a trauma to the abdomen capable of giving rise to all sorts of subcutaneous injuries, including intestinal rupture. Furthermore, a search should be made for fractures of the pelvis or elsewhere. The diagnosis, rupture of the bladder, can, however, only be made by means of roentgen examination with contrast medium in the urinary bladder. The latter can be done either by urography or by retrograde cystography.

Urography is recommended by many workers. PELKONEN is of the opinion that this is the best and least dangerous method. He further considers that urography is suited to all cases of rupture and that it is an essential requirement in the diagnosis of rupture of the neck of the bladder. WILMOTH claimed (1938) that urography is less risky than cystography, but that it should be remembered that the renal function may be temporarily impaired in the presence of shock and of injuries to the urinary passages. COE also emphasized the lesser risk involved in urography, but he had only one case of injury to the bladder demonstrated urographically. In the case in question, however, the bladder was not sufficiently damaged to allow the contrast to flood out. STEVENS and DELZELL used urography in one case only and then without a diagnosis.

It is thus found that, theoretically, cystography by means of intravenous injection of contrast medium is the most favorable method for making the diagnosis, rupture of the bladder, but that in practice it is attended by certain difficulties. In my opinion, this is mainly due to the fact that in urography the medium passes relatively slowly into the bladder and thus may flow out through the rupture and become mixed with the fluid in the abdomen, in which way it becomes diluted and hence gives a less dense shadow. Thus, the bladder will be diffusely outlined in the urograms, which may suffice for diagnosis, but will not provide the same certainty as is provided by retrograde cystography, with which *the medium can be seen passing through the rupture if the pictures are taken immediately after the injection*. Considerable fogginess appears only ten minutes after the injection, so that the rupture is seen less clearly outlined (fig. 8).

REXFORD claimed that cystography has no injurious effect whatever and does not delay convalescence. He had positive results with retrograde cystography in seven out of ten cases. STEVENS and DELZELL made positive findings in three out of four cases and CRANE and SCHRENK in thirteen out of fifteen. A sure diagnosis was secured in two of my cases and a probable diagnosis in the third.

What has been stated above regarding retrograde cystography applies

to examinations with positive medium. VOUGHAN and RUDNICK in 1924 described cystography using air, which in intraperitoneal rupture passes into the abdominal cavity and can be demonstrated under the dome of the diaphragm and in extraperitoneal rupture collects in the perperitoneal cavity. This method is also recommended by WILMOTH. PELKONEN on the other hand, pointed to the danger of air embolism with injection of air into a ruptured bladder, and mentioned that 34 of 791 physicians using the method described cases of air embolism in connection with it. In view of this, therefore, it is probably wise to avoid this method, even though it is perhaps the best one from a diagnostic viewpoint.

With regard to the differential diagnosis between intraperitoneal and extraperitoneal ruptures, it is known that if there are no pelvic fractures the rupture is practically always intraperitoneal, while if the pelvis is fractured the rupture is probably extraperitoneal. In addition, in extraperitoneal rupture the bladder is usually dislocated due to hemorrhage or the flow of urine into the perivesical space, which gives the picture of an expansive process in the true pelvis; in intraperitoneal rupture, on the other hand, the bladder is in its normal place. In my case No. 1, however, the conditions were reversed, the bladder being dislocated toward the rupture, obviously as a result of the hematoma from the fractures on the opposite side. However, I have seen one case of extraperitoneal rupture without fracture of the pelvis (perforation with the cystoscope through a bladder wall with tuberculous changes) in which the dislocation was of the type expected, i. e. away from the rupture.

Rupture of the bladder is a serious injury, and most statistics show the mortality to be high. The prognosis is greatly impaired if there is infection of the urinary passages before the accident. In addition, rupture of the bladder is often combined with other severe injuries, which can lead to death. Meanwhile, there is no doubt that in most cases the mortality depends on the length of time which elapses between the accident and the operation. DOBROWLSKAJA and WIEDMANN in 1914 had a mortality of 33.3 per cent for patients operated upon within 24 hours and of 85.7 per cent for cases in which a longer time elapsed. A lower mortality has been shown by statistics published after that date. In 1939 REXFORD had only two deaths among eleven cases. This reduction obviously depends on several factors, but undoubtedly a great part has been played by the increased possibilities of early diagnosis offered by roentgenologic examination.

## SUMMARY

The writer describes three cases of rupture of the urinary bladder and discusses the different diagnostic possibilities. Cystography by means of intravenous injection of contrast medium appears in theory to be the best method. It is attended by certain

difficulties, however. Retrograde cystography is a surer method from a diagnostic standpoint. With positive contrast medium, the latter method does not seem to involve any increased risk to the patient, but if air is used as a medium, there is a not insignificant danger of air embolism.

## ZUSAMMENFASSUNG

Verf. berichtet über drei Fälle von Ruptur der Harnblase und erörtert die differentialdiagnostischen Möglichkeiten. Die Cystographie mittels intravenöser Injektion eines Kontrastmediums erscheint theoretisch als die beste Methode. Sie ist jedoch mit gewissen Schwierigkeiten verknüpft. Die retrograde Cystographie ist — unter diagnostischem Gesichtspunkt — eine sichere Methode. Mit positivem Kontrastmedium scheint die letztere Methode keine erhöhte Gefahr für den Patienten in sich zu bergen, aber wenn Luft als Kontrastmedium angewandt wird, besteht erhebliche Gefahr, dass es zu einer Luftembolie kommt.

## RÉSUMÉ

L'auteur décrit trois cas de rupture de la versie et discute des diverses possibilités diagnostiques. La cystographie par injection intraveineuse de la substance opacifiante apparaît en théorie comme la meilleure méthode. Elle présente, cependant, certaines difficultés. La cystographie rétrograde est un procédé plus sûr du point de vue du diagnostic. Avec un milieu opaque «positif» ce procédé ne semble faire courir aucun risque surajouté au patient, mais si l'on recourt à l'injection d'air il existe un danger non négligeable d'embolie gazeuse.

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FROM THE MEDICAL CLINIC (HEAD: PROF. A. KRISTENSON) AND THE ROENTGEN-INSTITUTE (HEAD: DR. MED. E. LYSHOLM) OF THE SERAPHIMER HOSPITAL, STOCKHOLM

# BRONCHOGRAPHIC STUDIES IN ADVANCED SILICOSIS[1]

by

*Torsten Bruce* and *Gunnar Jönsson*

In the third stage of silicosis, the lungs become greatly contracted and deformed. The contraction and deformation are manifested in the roentgenogram in dislocation of the hilar shadows, so-called rain tracery (»Regenstrassen») running from the massive lesions to the diaphragm, and the clearing up of the pulmonary fields, resulting from the incorporation of the mottling with the conglomerate foci.

The best way to see how the lung is deformed by the contraction is by the injection of lipiodol into the bronchi. Bronchographic studies of silicosis have been done by a number of authors, e. g. THIIS-EVENSEN in 1941, but the topographic changes caused by the disease have not been given particular study.

Since we thought it would be interesting to see how the bronchial tree is deformed, we performed bronchography with lipiodol in a number of cases of third stage silicosis. This procedure shows more clearly than ordinary roentgenography the manner in which the main bronchi are dislocated by being pulled towards the centers of contraction. In addition, it enables a study of the disturbances in the position of the intrapulmonary air passages (Fig. 1). It was to be expected that the changes would be different depending upon whether the center of contraction had the situation characteristic of most forms of silicosis, superior, lateral and posterior to the hilus, or whether it was situated in the basal parts of the lungs. Five of the cases examined will now be reported; in the first four cases, two steel cleaners, one quartz miller and one porcelain worker, the center of contraction showed a characteristic localization, in the fifth, an iron ore driller, the massive lesions were situated basally.

[1] Submitted for publication Sept. 15, 1942.

*Case 1.* Mr. D. E. N—n, steel cleaner, born 1891. *Pulmonary roentgenography* showed closely packed, well circumscribed spots, situated symmetrically in both lungs, coalescing infraclavicularly into large, irregular, uniformly dense areas, situated postero-superiorly to the hilar shadows. There was contraction with dislocation of the hilar shadows laterally, upward and backward. Several egg-shell glandular calcifications were seen in the hilar regions. *Third stage silicosis.*

*Bronchography* on the right side (Fig. 2.): Only the ventral of the branches to the eparterial bronchus was filled with contrast matter. It was of ordinary width, but was displaced upwards and backwards. The apical and dorsal branches were only filled to a length of one centimeter, after which they tapered off to a point. The region of distribution of these bronchi corresponded to the site of the uniformly dense consolidation. The first ventral bronchus (the bronchus to the middle lobe) was greatly displaced upward, forming a rectangular bend 3—4 centimeters from its point of departure from the main bronchus. The second ventral bronchus was dislocated forward, but the dislocation was not so great as in the foregoing bronchus. The first dorsal bronchus showed slight dislocation of its upper branches upwards. Otherwise no dislocation of the dorsal branches was seen. All the bronchi which filled with contrast fluid were of ordinary width. — Thus the bronchographic examination revealed contraction in the upper lobe with considerable alteration of the topography of bronchial system, mainly affecting the eparterial and ventral bronchi; the apical and dorsal branches of the eparterial bronchus were probably obstructed.

*Case 2.* Mr. E. S. L—n, quartz miller, born 1890. *Pulmonary roentgenography* showed linear and mottled consolidations in both lungs, partly coalesced into homogeneous areas. The hilar shadows were dislocated posterosuperiorly as a consequence of the contraction.

*Bronchography* on the right side (Fig. 3.): The dorsal and ventral branches of the eparterial bronchus were only filled to a length of a couple of centimeters. The apical branch showed better filling, but only in its most lateral area of distribution did the contrast fluid run out into the fine ramifications. The rest of the upper lobe was taken up by the massive consolidation. The first ventral bronchus showed high-grade dislocation upwards and backwards, taking an almost rectangular bend about five centimeters from its point of departure from the main bronchus. The second ventral bronchus was likewise greatly displaced anteriorly and superiorly. The dorsal branches showed no definite dislocation, but the upper part of the main bronchus was dislocated slightly dorsally. All the bronchi filled with contrast matter were of ordinary width. — Thus the bronchographic examination revealed contraction in the upper lobe of the lung with considerable alteration in the topography of the bronchial system, mainly involving the ventral bronchi; there was probably multiple obstruction of the bronchi in the upper lobe.

*Case 3.* Mr. J. B. H—g, porcelain worker, born 1895. *Pulmonary roentgenography* showed small peaks on the domes of the diaphragms. Striated and mottled shadows were seen in both pulmonary fields, fusing laterally into large, coalescent foci. The hilar shadows were dislocated laterally and posteriorly.

*Bronchography* on the right side: Only the ventral branch of the eparterial bronchus was entirely filled with fluid. It exhibited considerable dislocation superiorly and posteriorly, forming an almost rectangular bend a few centimeters from the eparterial bronchus. The contrast matter entered the apical branch to a distance of about one centimeter. A few of the smaller branches of the latter were partly filled, but no contrast matter entered the dorsal branch. The first ventral bronchus showed great upward dis-

placement, and formed a downward opening angle in its middle part. The second ventral branch was dislocated forwards; the same was true to a certain degree of the lower part of the main bronchus. The upper dorsal bronchi were displaced upwards towards the center of contraction, which was situated mainly in the region of the dorsal branch of the eparterial bronchus. All the bronchi filled with contrast fluid were of normal width. — Thus the bronchographic examination showed contraction in the dorsal part of the upper lobe with considerable change in the topography of the bronchial tree, the alteration affecting both the dorsal and ventral bronchi and the eparterial bronchus. There was probably obstruction of the latter's apical and dorsal branches.

*Case 4.* Mr. J. A. L—n, steel cleaner, born 1888. *Pulmonary roentgenography* showed nodules up to the size of a pea infraclavicularly and in the middle fields on both sides. They had fused into a homogeneous consolidation infraclavicularly on the left side, and a similar tendency was seen on the right side. The lateral view showed the more homogeneous consolidations to lie farthest dorsally. Both hilar shadows showed considerable dislocation upward and backward.

*Bronchography* on the left side: The lower part of the trachea was dislocated posteriorly. Both main bronchi were pulled upward and laterally, the angle of bifurcation being greatly flattened out. The site of the homogeneously consolidated area corresponded to the regions of the dorsal branch and partly of the apical branch of the first hyparterial bronchus. The apical branch was dislocated dorsally and the ventral superiorly and dorsally. In the main, the ventral bronchi were dislocated so that they ran in arcs with the convexity upward, but the dislocation was not specially great.

*Case 5.* Mr. G. L. S—n, iron ore driller, born 1869. *Pulmonary roentgenography* showed well defined, mottled consolidations of the parenchyma, increasing toward the base, in both lungs. In the base of the right lung they coalesced into large, massive, irregular consolidations.

*Bronchography* on the right side (Fig. 4.): Only the ventral branch of the eparterial bronchus was filled with contrast fluid. It showed considerable downward displacement. The first ventral bronchus had a branch filled with fluid at the point of departure from the main bronchus, but the rest of its branches showed no filling until farthest peripherally. It seemed as though the filled branch ran through the massively consolidated area, where it showed diffuse narrowing and took a peculiarly stiff course. It divided into smaller ramifications, which led to the upper part of the massive lesion. At the border of the consolidation several of the bronchi ended abruptly. The second ventral bronchus was not filled. The dorsal bronchi were not displaced and were of ordinary appearance.

*Discussion.* It is evident from the foregoing cases that considerable displacement of the intrapulmonary bronchi takes places in third stage silicosis. The degree of displacement is directly dependent upon the amount of contraction. In the first four cases, where the center of contraction lay behind, above and lateral to the hilus, bronchography showed that the massive consolidation was situated largely in the upper lobe. The forces proceeding from this center as a result of the contraction caused deformation of the rest of the lung which agreed closely in all four cases, even though the contraction was not always of the same high degree. The regularity with which changes of similar appearance

Fig. 1.

occurred would indicate that in all cases of typical localization of the contraction foci the topography of the bronchi is changed in the manner described in our cases.

The ventral branch of the eparterial bronchus on the right side and of the first hyparterial bronchus on the left side was displaced upward

Fig. 2 a.

Fig. 2 b.

and backward. In one case where there was considerable displacement, the branch took a nearly right-angled bend. The first ventral bronchus as well, was always drawn cranialward, sometimes to a great degree. The humping of the bronchus a few centimeters from its place of origin, observed in cases of pronounced contraction, showed that the peripheral

Fig. 3 a.

supply area of the bronchus was not similarly changed in position. When there are adhesions between the pleural sheaths, they must form a hindrance to such a displacement. The second ventral bronchus as well, showed forward and upward displacement, though not so pronounced dislocation as the first ventral bronchus.

Sometimes the upper dorsal bronchi were displaced cranialward toward the center of contraction, but never to any great degree. When the center of contraction had a typical localization, the lower dorsal bronchi appeared to follow a completely normal course.

Fig. 3 b.

*The massive consolidation was mainly situated in the region of distribution of the eparterial bronchus on the right side and in the region of the first hyparterial bronchus on the left side.* The parenchyma supplied by the apical and dorsal branches of these bronchi was generally drawn into the massive lesion.

When the contraction sets in in a massively consolidated area,

Fig. 4.

situated in the usual place behind, lateral to and above the hilus, *it exerts the greatest pull on the ventrally situated bronchi.* In severe cases they are greatly dislocated anteriorly and upwards, and the pulmonary tissue surrounding them then first and foremost fills the space caused by the loss of parenchyma due to the development of the massive lesion. The ventral parts of the lung are rotated proximally, more so near the center of contraction than farther away, and more in the central than in the peripheral parts. *The contraction exerts only a slight effect on the position of the dorsal bronchi.* The bronchial tree thus retains its shape better in the dorsal than in the ventral parts of the lung.

In the cases where typical localization of the center of contraction does not occur so regularly, thus particularly in drillers in iron mines, the changes in the topography of the bronchi are subject to variations, dependent upon the position of the massive lesions. Case 5 shows how with basal localization of the contracting center the ventral branch of the eparterial bronchus was drawn downward, while the dorsal bronchi were not displaced. Moreover, there should not be the same amount of changes in the topography of the bronchial tree in third stage silicosis in drillers in iron mines as in silicosis from other industries, as the contraction occurs late in iron silicosis and seldom reaches a severe degree.

The bronchi in the parts of the lung not involved by consolidation were of normal width in the five cases reported. In the bronchi which led to the homogeneously consolidated areas, the shadow of the contrast fluid generally suddenly stopped at the border of the lesions, indicating that the bronchi were strangulated and lost their lumen when they were drawn into the consolidated area. In case 5, however, one bronchus filled with contrast fluid was seen to run through the massive lesion, where it appeared to be diffusely squeezed and ran a peculiar, stiff course. Some of its branches in the consolidated area were not filled with contrast fluid, probably because their thinner walls did not offer such great resistance to the obstructing influence of the contracting forces as the coarser main branch.

## SUMMARY

Bronchography allows an *intra vitam* study of the changes of the topography of the bronchial tree which occur when the contraction sets in in third stage silicosis.

When the center of contraction is situated characteristically, above, lateral to and behind the hilus, it exerts its greatest pulling effect on the ventrally situated bronchi, of which the proximal is dislocated upwards, so much that in severe cases right angles occur. The position of the dorsal bronchi is affected to a minor extent. The massive lesions are mainly situated in the eparterial bronchus' region of distribution on the right side and that of the first hyparterial bronchus on the left side.

When the center of contraction is not situated typically, the changes in the topography of the bronchi are subject to variations, depending upon the position of the massive lesions.

## ZUSAMMENFASSUNG

Die Bronchographie erlaubt, *intra vitam* die Veränderungen in der Topographie des Bronchialbaums zu studieren, welche auftreten, wenn die Kontraktion im dritten Stadium der Silikosis einsetzt.

Liegt das Kontraktionszentrum in characteristischer Weise oberhalb, lateral und hinten des Hilus, so übt es die grösste Zugwirkung auf die ventral belegenen Bronchen aus, und zwar werden die proximalen nach oben disloziert, sodass in schweren Fällen rechte Winkel entstehen. Die Lage der dorsalen Bronchen erfährt Veränderungen nur in geringerem Ausmass. Die massiven Gewebsveränderungen sind auf der rechten Seite hauptsächlich im Verteilungsgebiet des eparteriellen Bronchus und auf der linken Seite in demjenigen des ersten hyparteriellen Bronchus lokalisiert.

Hat das Kontraktionszentrum keine typische Lage, so zeigen die Veränderungen in der Topographie der Bronchen Variationen in Abhängigkeit von der Lokalisation der massiven Gewebsveränderungen.

## RÉSUMÉ

La bronchographie permet d'étudier *sur le vivant* les changements qui surviennent dans la topographie de l'arbre bronchique lorsque se produit la rétraction au troisième degré de la silicose.

Quand le centre de la rétraction occupe sa place caractéristique au-dessus, en dehors et en arrière du hile, son effet maximum d'attraction s'exerce sur les bronches situées du côté ventral, bronches dont celle qui est proximale est déplacée vers le haut, tant et si bien que dans les cas graves elle peut se couder à angles droits. La position des bronches dorsales est influencée dans une mesure moindre. Du côté droit les lésions massives sont principalement localisées dans la région de distribution de la bronche épartérielle, et du côté gauche dans celle de la première bronche hypartérielle.

Lorsque le centre de rétraction n'est pas typiquement situé, les changements dans la topographie bronchique sont sujets à varier, en dépendance de la localisation des lésions massives.

AUS DER RÖNTGENABTEILUNG DES KAROLINISCHEN KRANKENHAUSES, STOCKHOLM.
(VORSTAND: PROFESSOR ÅKE ÅKERLUND)

# ÜBER MAGENVOLVULUS[1]

von

*Nils Frostberg*

Volvulus ventriculi ist eine ungewöhnliche Krankheit, und oft ist die Diagnose erst bei der Operation oder bei der Sektion gestellt worden. Nur in einer kleineren Zahl von Fällen hat vor der Operation Verdacht auf diese Krankheit bestanden, die auch vorher nur selten diagnostiziert worden ist. Mitunter konnte Röntgenuntersuchung ausgeführt und die Diagnose hierdurch geklärt werden. An der Röntgenabteilung des Karolinischen Krankenhauses ist kürzlich ein Fall von Cancer ventriculi mit der Komplikation vollständiger Volvulus beobachtet worden. Da diese Krankheit selten ist, und da dieser Fall sich gewissermassen von anderen beschriebenen Fällen unterscheidet, dürfte eine Publikation berechtigt sein.

Es handelt sich um eine 78jährige Frau (Med. Krkg. 1559/42), 4-Para. Im Frühjahr 1940 wurde die Patientin wegen eines ziemlich rasch wachsenden Tumors in der linken Fossa iliaca in die hiesige gyn. Abt. aufgenommen. Dieser Tumor war kindskopfgross, verschiebbar, rundlich, gleichmässig und unempfindlich palpabel. Bei Laparotomie (LENNER) zeigte sich, dass der Tumor eine sehr bewegliche, zweifaustgrosse, deutlich vergrösserte Milz war. Abnorme Resistenzen in der Umgebung des Magens waren bei der Operation nicht palpabel. Eine hiernach vorgenommene Blutuntersuchung zeigte zahlreiche unreife, weisse Blutkörperchen, sowie leichte Anämie. Milzpunktion ergab die Diagnose myeloische Leukämie. Bei Röntgenuntersuchung mit Gasfüllung des Colons zeigte sich, dass die linke Colonflexur hoch oben im linken Hypochondrium und das Colon transversum hoch oben dicht am Zwerchfell lag. Das Colon transversum verlief schräg abwärts und vor dem Magen nach rechts. Im linken Hypochondrium war keine Milz zu beobachten. — Pat. bekam mehrmals Röntgenbehandlung und fühlte sich ziemlich wohl. — Am 3. IX. 42 wurde die Patientin in die Med. Abt. aufgenommen. Sie war müde und herunter. Mitunter hatte sie Schmerzen in der 1. Seite des Bauches und ab und zu Stechen bis hinauf zum Rippenbogen gehabt. Kein Erbrechen, kein Übelbefinden, der Appetit hatte aber abgenommen. Die Stühle waren in der letzten Zeit schwarz gewesen; Atemnot. Der Bauch war aufgetrieben, weich und nicht empfindlich. Bei Palpation wurde Milzvergrösserung festgestellt. Die Leber 2 Finger breit unter dem Rippenbogen. Am 5. 9. war Weber in den Fäzes +++, weshalb die Patientin einer Röntgenunter-

[1] Bei der Red. am 30. I. 1943 eingegangen.

suchung des Magens unterzogen wurde, die zweimal ausgeführt wurde, am 7. und am 10. 9. »*Magen:* Volvulus ventriculi. Der Magen hat sich ca. 180° um eine Horizontalachse gedreht. Der Ösophagus verläuft in der Mittellinie, und der Fornix ist ungefähr im Niveau von L. 1 und L. 2 belegen. Der Canalis liegt unter dem linken Zwerchfellgewölbe und enthält eine Gasblase. Auf Profilbildern macht es den Eindruck, als ob Canalis und Bulbus vor dem Ösophagus lägen, was sich aber, da diese ganz dicht aneinander liegen, nicht sicher feststellen lässt. Auf mehreren Bildern ist eine daumenspitzengrosse Weichteilmasse im Canalis zu beobachten, die von der Minorkontur ins Lumen hineinragt. Auf Profilbildern tritt diese bei Gasfüllung des Magens sehr deutlich hervor. Leider konnte die Untersuchung nicht so vollständig gemacht werden, wie es wünschenswert gewesen wäre, da die Patientin sehr mitgenommen war. Die Veränderung ist höchstwahrscheinlich durch einen Tumor bedingt, dessen Art jedoch röntgenologisch nicht bestimmt werden kann.» Man erörterte die Möglichkeit eines leukämischen Infiltrats oder eines wirklichen Tumors. Nach einem einige Wochen dauernden Krankenhausaufenthalt war Aszites nachweisbar, und am 29. 9. trat plötzlich der Tod ein.

Bei der *Sektion* fand man 5 000 ccm klare Flüssigkeit im Bauch. Keine Zeichen von Volvulus ventriculi, aber Bauchsitus eigentümlich, insofern als die mässig vergrösserte, feste, in ihren Hilusgefässen hängende Milz weit unten in der Mitte der Bauchorgane liegt, unterhalb vom Colon transversum, und von radiär angeordneten Darmschlingen umgeben ist. Gewicht der Milz 245 g. Der Mageninhalt war schwarz-braun. Auf der Minorseite des unteren Teiles des Corpus und im Canalis sitzt eine gut handflächengrosse, teilweise ulzerierte, gesprenkelte, weisse Cancermasse, die das Omentum minus infiltriert und schrumpfend die obere Partie des Canalis und Duodenums hinaufzieht. Die Leber ist von unzähligen bis pflaumengrossen, teilweise nekrotischen Metastasen ganz durchsetzt. Mikroskopische Untersuchung: Magen: Ziemlich niedrig differentiiertes *Adenokarzinom*. An mehreren Stellen Schleimbildung.

*P. A. D.: Cancer ventriculi + Myelose.*

Im oben mitgeteilten Fall war also bei zwei Röntgenuntersuchungen mit 3tägigem Intervall ein vollständiger Volvulus ventriculi nachweisbar. Die Patientin hatte keine deutlichen Beschwerden vom Magenvolvulus als solchem gehabt. Bei der Obduktion hatte der Magenvolvulus der Patientin sich gelöst. Man fand nur einen Cancer im Magen, der das Omentum minus infiltrierte, und die obere Partie von Canalis und Duodenum durch seine Schrumpfung hinaufzog. Die durch die Myelose vergrösserte Milz der Patientin lag weit unten links im Bauch, war also ptotisch, und dürfte durch das gleichzeitige Hinabziehen des Fornix des Magens zur Entstehung von Volvulus beigetragen haben.

Volvulus ventriculi ist zuerst von Berti, 1866, beschrieben worden, der folgendes bei einer Obduktion beobachtete: Eine Vorwärts-Aufwärts-Rotation des ganzen Magens um 180° mit Ausnahme des subdiaphragmatischen Teiles des Fundus, wodurch die Curvatura major oben unter dem Zwerchfell lag. Sodann folgten kasuistische Mitteilungen auch von anderer Seite. Eingehender ist die Krankheit von Payer, v. Haberer, Kocher, Buchanan, Singelton u. a. beschrieben worden. In Skandinavien haben Helsingen und Tøllbøll im Anschluss an eigene beobachtete Fälle ausgezeichnete Beschreibungen von der Symptomatologie und

den Entstehungsbedingungen dieser Krankheit geliefert. LÄWEN soll bis zum Jahre 1927 40 Fälle in der Literatur gefunden haben. Es sind sodann weitere Fälle publiziert worden, insgesamt schätzungsweise etwa 60 an der Zahl.

Abb. 1. Eigener Fall. Mesenterio-axialer Volvulus ventriculi. Die Minorseite des aufwärtsrotierten Magenteiles weist auf einem 3—4 Querfinger langen Gebiete steife, zerrissene Konturen auf, und in das Lumen des Canalis ragt ein Tumor hinein.

Man kann die Volvulusformen in *partielle* und *totale* einteilen, je nachdem ob ein Teil des Magens an der Drehung beteiligt ist oder der ganze Magen. Eine andere Einteilung berücksichtigt die Rotationsachse, daher die Bezeichnung mesenterio-axiale oder organaxiale. Auch ätiologisch kann man verschiedene Gruppen aufstellen. Die partiellen kommen am häufigsten bei Sanduhrmagen vor, während die totalen meistens idiopathisch sind. Im allgemeinen scheint an das Bestehen eines wirklichen Volvulus die Bedingung geknüpft zu sein, dass die Drehung 180° oder mehr beträgt. Bei einzelnen Gelegenheiten sind Drehungen von mehr als 180° beobachtet worden. KOCHER hat die beste Einteilung der verschiedenen Volvulustypen vorgenommen; diese scheint auch von den meisten Autoren angenommen zu sein.

Nach KOCHER kann man mit zwei Typen rechnen. Der häufigste ist der *mesenterio-axiale*, wo der Magen um eine Achse rotiert, die durch das Omentum minus und durch das Corpus ventriculi geht und im rechten Winkel zur Längsachse des Magens verläuft. Die Längsachse des Magens von der Cardia bis zum Pylorus verläuft normalerweise schräg von oben links nach unten rechts. Nach der Drehung liegt der Pylorus schräg aufwärts und nach links, während der Fornix schräg abwärts nach rechts läuft. Der Magen wendet sich fast immer längs der vorderen Bauchwand nach vorn, so dass bei voll ausgebildetem Zustand die Rückseite des Magens nach vorn gerichtet und vom Omentum majus bedeckt ist (Abb. 2). Eine Variante hierzu finden wir beim Sanduhrmagen, die vertikal stehende Rotationsachse (Abb. 3). Hier rotiert der horizontale, untere Magenteil. Im letzteren Falle haben wir also im Grunde genommen nur einen teilweisen Volvulus vor uns.

Der andere, ungewöhnlichere Typ ist der *organ-axiale* (Abb. 4), wo der Magen sich um seine eigene Längsachse dreht. Auch hier finden wir

Abb. 2.

Abb. 2. Volvulus mesenterio-axialis (nach KOCHER).

ab. Die schrägverlaufende mesenteriale Drehungsachse.
cd. Die Drehungsrichtung des Pylorusteiles nach oben über die Vorderseite des Magens.
e. Die Richtung abwärts-rückwärts, die der Fornix einnimmt.
f. Omentum minus.
g. Lig. hepato-duodenale.

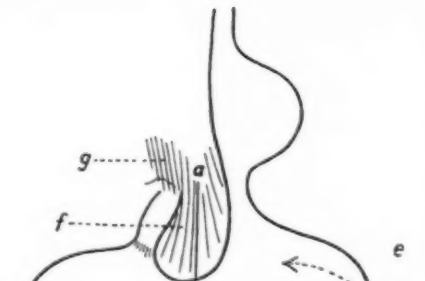

Abb. 3.

Abb. 3. Volvulus mesenterio-axialis (nach KOCHER).

ab. Die lotrecht stehende mesenteriale Drehungsachse.
cd. Die Drehungsrichtung des Pylorusteiles nach links quer über die Vorderseite des Magens.
e. Drehung des Fornix nach rechts an der hinteren Bauchwand entlang.
f. Omentum minus.
g. Lig. hepato-duodenale.



Abb. 4.

Abb. 4. Volvulus organo-axialis (nach KOCHER).

ab. Die Drehungsachse.
cd. Die Drehungsrichtung der Curvatura major nach hinten oben zum Omentum minus und oberhalb der Curvatura minor.
hi. Die Drehungsrichtung der Curvatura major nach vorne oben.

gewissermassen zwei Unterarten, je nachdem wie das Curvatura-major-Gebiet abschwenkt. Am häufigsten rotiert dieses nach hinten längs der hinteren Bauchwand nach rechts oben hinter dem Omentum minus. Weniger häufig dreht sich die Curvatura major längs der Vorderseite und über der kleinen Kurvatur.

Omentum majus und Colon transversum verhalten sich wohl bei den verschiedenen Volvulusformen etwas verschieden. In der Regel werden sie mit hinaufgezogen, so dass der Magen unterhalb vom Colon liegt. Wir haben so den Typ Volvulus ventriculi *infracolicus* vor uns. Volvulus ventriculi *supracolicus* mit dem Magen über dem Colon ist selten und setzt nach BUCHANAN ein enorm langes und schlaffes Omentum majus oder eine Ruptur desselben voraus. Eine Aufteilung der verschiedenen Volvulusformen nach der Lage des Magens im Verhältnis zum Colon (infra-resp. supracolicus) hat BORCHARDT vorgenommen, die Einteilung KOCHERS scheint aber die beste zu sein. Es können natürlich Varianten und auch Kombinationen der verschiedenen Formen vorkommen. So kann nach der Ansicht von TØLLBØLL in seltenen Fällen bei der organ-axialen auch eine mesenterio-Axialdrehung vorkommen.

PAYER, der die in Rede stehende Krankheit im Jahre 1909 ausführlich beschrieb, nahm eine gute Einteilung vor, die mehr auf die Ätiologie zielte. Er teilte die Ursachen in 5 Gruppen auf:

1. Volvulus ventriculi bei Hernia diaphragmatica.
2. » » » Magengeschwülsten.
3. » » » entzündlichen Prozessen.
4. » » durch Lageveränderung der benachbarten Organe.
5. Idiopathischer Volvulus ventriculi.

Volvulus bei Hernia diaphragmatica soll nach WIETING darauf beruhen, dass das Omentum majus in den Bruchsack hineinwandert, festwächst, schrumpft und den Magen mitzieht. Es entsteht eine teilweise Drehung nach vorn. Nach PAYER ist dies eine plausible Erklärung. Es hängt sodann von der Geräumigkeit des Bruchsackes und von der Grösse der Bruchpforte ab, ein wie grosser Teil des Magens in den Bruch hineingezogen wird, und wie gross die Drehung ist. Unter 500 referierten Fällen von Zwerchfellbrüchen fand PAYER 12 mit Volvulus ventriculi.

Nur einige Fälle von Volvulus bei Geschwülsten sind früher beschrieben worden. Nach PAYER würden die besten Voraussetzungen hierfür bei den gutartigen Magentumoren sowie bei Sarkomen bestehen. KAUFMANN hat einen benignen Magentumor (Fibromyom) beschrieben, der kindskopfgross war (Gewicht 2.325 g). Er sass an der Curvatura minor und hatte den Magen ins Kleinbecken hinuntergestülpt und diesen dabei um die Längsachse rotiert. Dass Volvulus bei Cancer ventriculi eine so ungewöhnliche Komplikation ist, beruht nach PAYER darauf, dass der Magen zu früh an den benachbarten Organen fixiert wird, als dass eine Drehung zustandekommen könnte. Es scheinen nur zwei derartige Fälle beschrieben worden zu sein, einer von PAYER und einer von v. HABERER. Es ist möglich, dass v. HABERER Recht hat, wenn er hervorhebt, dass die Beschwerden von wechselndem Typ, über die ein Patient mit Cancer

ventriculi klagt, so mannigfaltig sind, dass ein Teil von ihnen sehr wohl von Lageveränderungen des Magens herrühren kann.

Bei den entzündlichen Prozessen handelt es sich um perigastritische Adhärenzen, hauptsächlich im Anschluss an Ulcus. Hierher gehört die Mehrzahl der beschriebenen partiellen Volvulusfälle bei Sanduhrmagen (vgl. oben S. 219).

Veränderte Lage der Nachbarorgane vermag natürlich Lageveränderungen des Magens herbeizuführen. Hier scheint es sich, wie meistens um ein von Gas ausgedehntes Colon zu handeln. SINGELTON hat indes eingewendet, dass der Magen wohl verschoben, aber nicht hochgradig rotiert werden kann. LAMARQUE, MORQUE-MOLINES, BÉTOULIÈRES, GINESTIÉ haben einen Fall von totalem Magenvolvulus bei einer 50jährigen Frau beschrieben, bei der eine vergrösserte, im linken unteren Teil des Bauches gelegene gedrehte Milz durch Zug an der Fornixpartie des Magens zur Entstehung eines Volvulus beigetragen haben soll. Dieser Fall hat grosse Ähnlichkeit mit dem unsrigen, bei welchem jedoch ausserdem die Komplikation Magencancer bestand.

Was schliesslich die Fälle von idiopathischem Volvulus ventriculi betrifft, so sagt schon der Name, dass eine sichere Erklärung für diese nicht möglich ist. Abnormitäten in den Mesenterien hält SINGLETON für eine denkbare Ursache. PAYER tritt dafür ein, dass gefüllter Magen, »Gastroptose» und Hypermotilität zu dieser Krankheit prädisponieren. Nach TØLLBØLL können nur »Gastroptose» und Hypermotilität eine Rolle spielen, während die Füllung, die zunächst als sekundär zu betrachten ist, eher den Bewegungen entgegenarbeiten sollte. SIEGEL und v. HABERER wollen diese Erscheinung durch mangelhaftes Zusammenwirken zwischen den drei Muskelschichten des Magens erklären. TØLLBØLL ist der Auffassung, dass diese isolierten Muskelkontraktionen allein wahrscheinlich keinen Volvulus herbeiführen können. ROSENBERGER hat gezeigt, dass 70 % der »Gastroptosen» Hypomotilität aufweisen, 20 % dagegen Hypermotilität. »Gastroptose» im Verein mit Hypermotilität (nach BUCHANAN starke Peristaltik, der antiperistaltische Wellen folgen) und ein langes Ligamentum hepato-duodenale hält PAYER aus diesem Grunde für prädisponierend. Diese Annahme haben deutlich die meisten gebilligt, die versucht haben, für die idiopathischen Volvulusfälle eine Erklärung zu finden. In zwei Fällen soll nach BUCHANAN zweifellos ein Trauma den Volvulus ventriculi ausgelöst haben. Da diese Krankheit gewöhnlich Individuen in den mittleren Jahren oder Ältere trifft (SIEGEL hat allerdings Volvulus ventriculi bei einem 2Jährigen gefunden, und DUJON bei einem 5Jährigen), Frauen vielleicht etwas häufiger, ist zu vermuten, dass in den meisten Fällen ein gewisser Grad von Ptosis vorgelegen hat.

Die Symptome von akutem Volvulus ventriculi kommen denen, wie sie bei Ileus im oberen Teil des Bauches auftreten, am nächsten. Ohne

vorausgegangene Symptome bekommt der Patient plötzlich heftige Schmerzen im Bauch und Erbrechen des Mageninhaltes. Ziemlich bald sind die Brechversuche resultatlos; es kommt nichts herauf.

Der Patient kann nichts schlucken, und es lässt sich keine Sonde in den Magen hinunterführen. Gelingt eine Röntgenuntersuchung des Magens, so spricht dies nach TØLLBØLL gegen akuten Volvulus. Epigastrium und Hypochondrien dehnen sich oft enorm aus, und bei Perkussion zeigt sich starker Tympanismus. Diese Symptome dürften darauf beruhen, dass sich erst der Pylorus schliesst (wie TUFFIER experimentell gezeigt hat), und dann die Cardia, worauf der Magen sich ausdehnt. Die partiellen Formen weisen oft ebenso wie die chronischen Zeichen einer früheren Magenanamnese auf, und das Krankheitsbild scheint hier nicht so stürmisch zu sein.

Die Diagnose Volvulus ventriculi ist klinisch schwierig. In der Regel denkt man an andere akute Krankheiten im oberen Teil des Bauches, perforiertes Ulcus, Ileus, akute Pancreatitis oder mesenteriale Embolie. Diejenigen Fälle, wo Volvulus vor der Operation oder vor der Sektion diagnostiziert worden ist, sind sehr gering an der Zahl, und in denjenigen Fällen, wo man röntgenologisch Volvulus nachweisen konnte, hat es sich in der Regel um ein weniger stürmisches Krankheitsbild gehandelt. WEISS (1922) hat als Erster Volvulus ventriculi röntgenologisch beschrieben, aber es handelte sich in diesem Falle um einen partiellen Volvulus des unteren Teiles des Magens um die organ-axiale Achse. Totaler Volvulus nach der mesenterio-axialen Achse haben u. a. CAILLODS und COLLET in sehr schönen Bildern gezeigt (Abb. 5). Bei den akuten Formen tritt Stenose an der Cardia ein, wodurch niemals ein Kontrastmittel in den Magen hinuntergelangt.

Was die mit der Drehung selbst verbundenen Komplikationen betrifft, soll BORCHARDT Rupturen der Milzgefässe mit profuser Blutung beobachtet haben. KERR hat Ruptur des Ligamentum gastrocolicum beobachtet, und in HELSINGENS Fall hat man Rupturen in der Serosa des Magens festgestellt, die bei Repositionsversuchen dazu neigten, stärker zu werden, weshalb man hier ebenso wie in den meisten Fällen damit beginnen musste, den Magen durch Punktion zu entleeren. LÄWEN fand in dem von ihm beschriebenen Fall eine Ruptur in der nach vorn gedrehten Rückwand des Magens mit lokaler Peritonitis.

Die Therapie ist in den akuten Fällen zweifellos chirurgisch. Entleerung des ausgedehnten Magens mit dem Schlauch ist infolge des Hindernisses an der Cardia unmöglich. In der Regel muss der Magen vor der Reposition mittels Trokar punktiert und von Gas und flüssigem Inhalt entleert werden, worauf die Reposition in der Regel leicht durchführbar ist. Die chronischen Formen sowie die partiellen, wo keine eigentlichen Beschwerden durch die Drehung selbst vorliegen, verlangen keinerlei Eingriffe.

Abb. 5. Nach CALLOIDS et COLLET. Totaler Magenvolvulus nach der mesenterio-axialen Achse.

v. HABERER hebt hervor, dass ohne Zweifel Fälle von Volvulus ventriculi vorkommen, die spontan zurückgehen.

Die Operationsprognose bei den idiopathischen Formen scheint in der Mehrzahl der Fälle relativ gut zu sein unter der Voraussetzung, dass der Patient früh einer Behandlung unterzogen wird. TØLLBØLL erwähnt, dass 10 von 34 Volvulusfällen erst bei der Sektion diagnostiziert worden sind. Von den 24 operierten starben 6 im Anschluss an die Operation, während 18 gesund wurden. Die Prognose der partiellen wie auch der chronischen Formen richtet sich natürlich nach der Krankheit, die dahinter steckt.

## ZUSAMMENFASSUNG

Verf. beschreibt einen röntgenologisch diagnostizierten Fall von totalem Volvulus ventriculi nach der mesenterio-axialen Achse mit einem Cancer ventriculi. Gleichzeitig lag eine myeloisch vergrösserte Milz mit Ptosis vor, die eine beitragende Ursache für die Entstehung des Magenvolvulus gewesen sein dürfte. Verf. stellt vergleichende Literaturstudien an im Hinblick auf pathologische Anatomie, Ätiologie, Diagnose, Therapie und Prognose.

## SUMMARY

The author describes a roentgenologically diagnosed case of total gastric volvulus in the mesenterio-axial axis with gastric cancer. At the same time, the pancreas exhibited myeloid enlargement with ptosis, which was assumed to have been a contributory

cause of the gastric volvulus. A comparative study of the literature was made, with regard to pathology, etiology, diagnosis, therapy and prognosis.

## RÉSUMÉ

L'auteur décrit un cas — diagnostiqué radiologiquement — de volvulus total de l'estomac, qui était le siège d'un cancer, et ayant pour axe celui du mésentère. En même temps existait une hypertrophie myéloïde de la rate avec ptose, que l'auteur considère comme cause adjuvante du volvulus stomacal. Compte-rendu des recherches bibliographiques comparatives touchant l'anatomie pathologique, l'étiologie, le diagnostic, le traitement et le pronastic.

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# ON THE DIVISION OF THE LUNG SEGMENTS (III)[1]

by

Dr. *W. J. Pothoven* and Dr. *Eelco Huizinga*

In previous communications one of us (1), together with BEHR †, Prosector of the Pathological-anatomical Laboratory, pointed to the importance of the division of the lung into segments. This division depends on the ramification of the bronchial tree. We already described the right upper lobe and the left lung, which investigation is now completed by the study of the conditions in the right middle and lower lobe.

Altogether 134 right lungs were investigated. In most cases it was sufficient to cut the air passage open from the hilus by a pair of scissors after which a good impression of the ramification was obtained. In some instances, especially for the middle lobe, we used the method of injection with coloured paraffin which is previously described. The extent of the segments, especially at the periphery, can then more plainly be seen. For the lower lobe a better image was obtained by the following method: insertion of probes into the various bronchi and then furnishing the ends of the probes with coloured pellets of plasticine. This was done with lungs which were fixed in inflated condition. For the fixation it was most satisfactory to inject the formaline under slight overpressure into the fresh preparation, after which the bronchus was tied off and the whole lung was brought into a cask with formaline.

Before the ramification of the bronchi was investigated, an external inspection of the lung was made. In this way various particularities can already be seen, inter alia a fissure by which a segment appears in well-defined outlines on the surface (see fig. 4). In 13 lungs, i. e. in about 10 per cent, the formation of the lobes was abnormal. Invariably in this case the upper and middle lobe had grown together. If this is complete, two lobes are found on either side: hereby the right lung is almost the counterpart of the left one. The question of the homology

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of the lung lobes is less actual at present than it was at the time of AEBY (2). In making a comparison, this inspection of the lungs convinces us that the left upper lobe is homologous to the right upper + middle lobe, whereby the lower anterior segment of the left upper lobe, including inter alia the lingula, shows a great likeness to the middle lobe.

As known, in different mammals, f. i. in camel, elephant, hippopotamus and orang-utan, the lungs are not divided into lobes. According to MARCUS (3) the lobes have atrophied by an alteration in living, in which a reduced consumption of oxygen plays an important part. This, however, causes no particular variation of the ramification of the bronchial tree, which, both in orang-utan and in human beings, is nearly identical. In those cases, where on the right side only two lobes are found, the middle lobe bronchus was invariably found at the normal place.

*1. The middle lobe.* Without exception this lobe is served by one separate bronchus which always goes off ventrally. The bronchus splits constantly dichotomically, usually into a medial and a lateral branch. Generally the medial branch serves the anterior part and the lateral branch the posterior part of the middle lobe. In some instances the branches proceed (also as far as the height is concerned) in a different level, the medial branch can be found both above and below the level of the lateral one. In a minor part of the cases (in about 10 per cent) distinct lower and upper branches are present. The middle lobe can therefore be divided into two segments; after injection with paraffin it appears that these segments are invariably distinctly delimited. In literature some cases are described where a bronchiectasis was localised in the medial or lateral segment only.

*2. The right lower lobe.* The construction of the lower lobe is as complicated as that of the right middle lobe is simple. HEISS (4) already spoke of a maze of bronchi stretching out in a fan-shaped way, in which a definite scheme was difficultly to be distinguished. The few attempts, made in this direction, often make use of the scheme given by AEBY (5), who attached much importance to the stem bronchus which he could follow through the whole lung until the periphery in the niche between spinal column and diaphragma. From this branch several smaller branches go off regularly. AEBY distinguished 4 ventral and 4 dorsal bronchi. On the right side the first ventral forms the middle lobe bronchus, hence the lower lobe is served by 3 ventral and 4 dorsal bronchi.

AEBY already pointed to the fact that it was more difficult to follow the trunk bronchus in the human lung than in mammals. Generally this stem bronchus is not thought to be of so much importance at present as at the time of AEBY. However, AEBY, who first investigated the bronchial tree, had already a good notion of its ramification. He did not

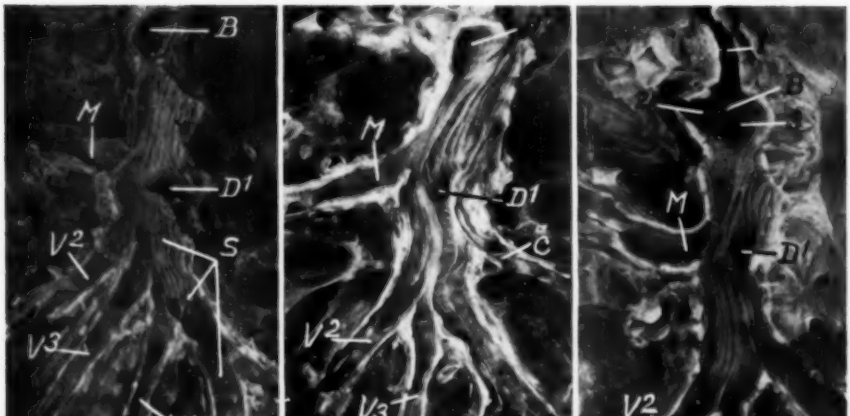


Fig. 1. Fig. 2. Fig. 3.

Three lung preparations of adults, in which the bronchi of the right lung are cut open from medially.
B = upper lobe bronchus. For the other letters see text.

take the anatomical variations into account, nevertheless there are cases for which the scheme of AEBY can satisfactorily be used. A very good example of this is illustrated in fig. 1. In the lower lobe a bronchus is seen which can be indicated as the stem bronchus S., under the middle lobe bronchus ($M = V_1$) 3 ventral branches ($V_2$, $V_3$ and $V_4$) can plainly be seen. Fig. 2 shows the anatomy of another bronchus; $V_2$ and $V_3$ jointly go off, hence it is difficult to speak here of a »trunk bronchus». Fig. 3 gives a bifurcation into a large ventral and a much smaller dorsal branch; the first comprises $V_2$ as well as $V_3$. Considered in the sense of AEBY here the stem bronchus should not be situated laterally but ventrally.

The first large branch, constantly present, is the first dorsal one, $D_1$, the orifice of which can clearly be seen in fig. 1—3. This proceeds constantly opposite to, although somewhat below the middle lobe. Hence this is the first segment, which comprises the apex of the lower lobe. In almost 10 per cent of the cases a delimitation of this segment was formed by a fissure which sometimes gave the impression of a 4th lung lobe. Fig. 4 shows at a an example of it. Especially in adults this segment is larger than in fig. 4, on the dorsal side it often passes the medium of the lower lobe. On the ventral side this segment usually

ends higher, the boundaries downward run from the lower back to the upper front. In some exceptional cases this segment is served by two smaller dorsal branches which take origin so close together that it gives the impression that these are the two branches in which soon $D_1$ ramifies regularly.

Fig. 4. Right lung of neonatus.

The anatomy of this segment is as the so called »Lobe moyen dorsal» studied especially by French investigators, a. o. PIERRET and his collaborators (6). In this segment inflammations are often localised; a typical affection of this part of the lung is a pneumonia with an unusually lingering course. The name »middle dorsal segment» is explained by the fact that the upper dorsal segment is localised in the upper lobe. LUCIEN and his co-operators were of the opinion that 4 segments were present; a previous investigation of us, however, added support to the conclusions of FELIX and HERRNHEISER. These last investigators found as a rule 3 segments in the right upper lobe: an apical, a pectoral and an axillary one.

AEBY described the so-called cardial bronchus, a particular branch, invariably present, taking a separate place out of the system of the ventral and dorsal bronchi. This branch proceeds medially between $V_1$ and $V_2$ and can clearly be seen in fig. 2 at C. As known, many mammals have a lobus cardiacus apart, phylogenetically this is even the oldest lobe.

It appears that this bronchus cardiacus can easily be misappreciated when the usual way of preparation is followed. If the bronchus is cut open with a pair of scissors from the hilus, i. e. from the medial side, the cardial bronchus lies just in the level of the intersection, which is the reason that it is easily overlooked. The cardial bronchus is not found in all cases; in a major part of the lungs, however, in our cases in about 75 per cent, it was present. The localisation is always the same as described by AEBY, the bronchus goes off medially between $V_1$ and $V_2$. A small medial part of the lung, on the front side of the lower lobe, lying immediately below the hilus, close to the heart, and a small part of the facies diaphragmatica anterior-medially, are served by it. In some exceptional cases an indication of a fissure is found, by which the segment is then seen at the surface of the lung. In our cases the separation, however, was never so pronounced that, just as in the 1st dorsal segment, a separate long lobe could be accepted. Therefore we have to draw the conclusion that a lobus cardiacus infrequently if ever occurs in man.

By some clinicians, a. o. KARTAGENER and his collaborators (7), the presence of a lobus cardiacus is considered to be of much importance; in such a so-called accessory lung lobe, a bronchiectasis would often develop. This diagnosis was nearly always made by the roentgenological examination; some reproductions of roentgen photographs gave the impression that in reality nearly always a marked diminution of the lower lobe was present. We saw some cases in which usually by a foreign body, a bronchiectasis had developed, only in that part which was served by this cardial bronchus. This affords reason to consider this lung part as a separate segment.

After the anatomical investigations it is not clear to us why generally disturbances would sooner develop in an accessory lung lobe. The relations of the bronchi and the art. pulmonalis, probably also of the other lung tissue, remain the same, except that the delimitation of this normally also present lung segment has become more pronounced by a fissure. It is difficult to conceive that a condition as is illustrated in fig. 4 would sooner cause disturbances in the first dorsal segment. In that case it had to be accepted that in this regard the fact that the middle lobe has grown together with the upper lobe should be favorable. It gives the impression that here harmless anatomical variations are present.

The $V_2$ of AEBY, i. e. the 1st ventral branch of the lower lobe bronchus is in most cases present as a separate branch, sometimes rather small sometimes larger, its origin is usually just below the middle lobe bronchus. This branch serves a segment which lies just under the middle lobe. In three cases this segment was delimited on the surface by a fissure. Exceptions: in one case, evidently a very rare one, $V_2$ springs off from the middle lobe bronchus; in 7 cases $V_2$ and $V_3$ spring off together, type fig. 3.

Finally, for a further division, there remains the largest lower part, which comprises the $V_3$ and $V_4$ and the $D_2$, $D_3$ and $D_4$ of AEBY. The division of these branches is, however, not constant. In a number of cases a bronchus was found, corresponding with the $V_4$ of AEBY, but which varied in size (for comparison see f. i. fig. 1 and 2). Also the number of ventral bronchi is varying. In the dorsal bronchi the differences are still more pronounced. In agreement with AEBY, under the invariably present $D_1$ 3 dorsal bronchi were found, sometimes 2, sometimes 4. After the ramification of $V_2$, there invariably is a bifurcation into a mediodorsal and a ventro-lateral branch; according to AEBY the first is the trunk bronchus, the second is the $V_3$. This ramification has also been described previously for the left side; here, however, the branches are more alike. On the right side the dorsal-medial branch is usually larger; we found this in 60 per cent of the lungs. Two thirds of the remaining 40 per cent had about equal branches, in one third the ventro-lateral

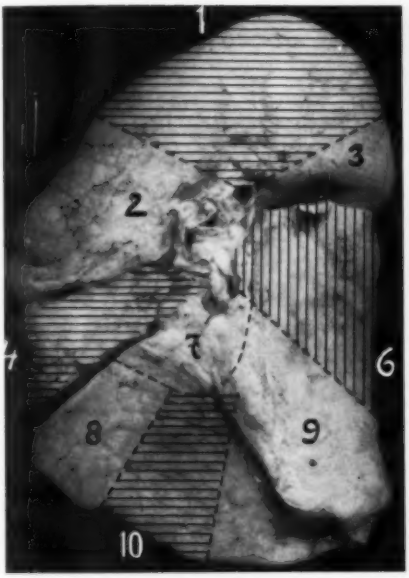


Fig. 5. Right lung, taken from medially.

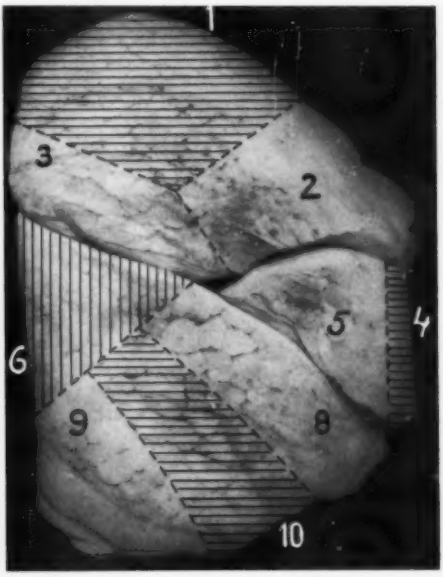


Fig. 6. Right lung, taken from laterally.

branch was wider. In both branches a ramification usually soon develops; a large branch goes off laterally, its origin being plainly visible in the opened preparation. These are the same bronchi which are described for the left side as the so-called »head-lamps». Here also one of the lateral branches goes off somewhat higher, sometimes above the ramification, sometimes upon the ramification itself. Hence in the last case there exists a trifurcation.

It seems nearly impossible to make a further division into several segments of this lung area, by which a scheme would be given which is valuable for the major part of the cases. The anatomical variations are too numerous. Just as on the left side, it is better to stop at this rather constant bifurcation, forming two segments, a ventral and a dorsal one, which completely fulfil the requisite conditions described in a previous communication.

Hence in this way the right lower lobe is divided into 5 segments. Fig. 5 and 6 show an inflated right lung, photographed from medial and lateral. The 10 segments are numbered and indicated by means of different hatchings. In the upper lobe three segments are found: 1. the apical, 2. the pectoral and 3. the axiallary segment; in the middle lobe two segments: 4. the medial and 5. the lateral segment; in the lower

Fig. 7.

lobe five segments: 6. the upper dorsal, 7. the cardial, 8. the upper ventral, 9. the lower dorsal and 10. the lower ventral segment. This scheme, made after a given case, has only value for the major part of cases. As stated in a previous communication the number of anatomical variations, especially in the upper and lower lobe, is so numerous, that in clinical cases a bronchography has to be carried out in order to obtain a definite localisation.

On the roentgen picture fig. 7 with lipiodol most of the above described branches can plainly be seen, they are numbered according to the segments of fig. 5 and 6.

There is still another advantage in making no further division of the lower lobe than into 5 segments. The entrance of 5 afferent bronchi can be plainly seen in bronchoscopy, under normal circumstances a further insertion of the tube is nearly always impossible. In a number of cases a distinct localisation of the affection has already been obtained before the bronchoscopy (foreign body, many tumours), often it is localised in the main bronchus and one can go straight to the point. Sometimes, however, the endoscopist is asked whether it is possible to establish from which part of the lung the pus or blood is coughed up. All the ramifications must then be examined systematically for which a knowledge of this anatomy and of the chief anatomical variations is absolutely necessary. The different bronchi can be entered with the tube by moving the head of the patient to the left, to the right, upward and downward.

The *systematical bronchoscopy* (in recumbent position) must, on the right side, be performed as follows. After determination of the bifurcation, the tube is inserted into the main right bronchus. The upper lobe bronchus soon goes off laterally, the orifice can be found by moving the head far to the left (BRÜNINGS, JACKSON). The further ramifications

cannot be seen. The head is replaced to its original position, the tube is moved on some centimetres further, by which the ramifications of the lower lobe bronchus can be seen in the depth. The next branch is the middle lobe bronchus, which goes off plainly ventrally, the mouth can be seen by displacing the head far downward. At a somewhat lower level the large first dorsal bronchus of the lower lobe follows. Now the head must be brought upward. Then it is returned to its usual position, after which the tube is inserted into the lower lobe bronchus. Now the cardia bronchus follows, which goes off medially and can easily be failed by bronchoscopy. The orifice can be found by turning the head to the right. After 1—2 cm. the first ventral bronchus of the lower lobe is seen which must be inserted in the same way as the middle lobe bronchus. Finally the inspection of the medio-dorsal and latero-ventral ramification of the lower lobe bronchus is made.

## SUMMARY

In continuation to previous investigations a description is given of the division of the segments in the right middle and lower lobe which depends on the anatomy of the bronchial tree. This is very constant in the middle lobe, the bronchus springs off ventrally and soon splits into a medial and a lateral branch. The constructions in the lower lobe are much more complicated as many anatomical variations are found. The first constant large branch is the 1st dorsal bronchus followed by the cardial bronchus which is usually present; the next branch, a ventral bronchus, is infrequently absent as a separate branch. Finally a ramification into a medio-dorsal and a ventro-lateral branch follows. Hence it is found that 5 segments are present.

A review is given of the segments of the right lung and of the way in which a systematical bronchoscopy on the right side has to be performed.

## ZUSAMMENFASSUNG

Im Anschluss an frühere Untersuchungen wird eine Beschreibung gegeben über die Segmentierung des rechten Mittel- und Unterlappens, welche abhängig ist von der Anatomie des Bronchialbaumes. Diese ist sehr konstant in dem Mittellappen, der Bronchus geht ventral ab und teilt sich bald in einen medialen und einen lateralen Ast. Die Verhältnisse in dem Unterlappen sind viel komplizierter, hier werden viele anatomische Variationen gefunden. Der erste konstante grosse Ast ist der erste dorsale Bronchus, der gefolgt wird von dem cardialen Bronchus, welcher gewöhnlich anwesend ist; der folgende Ast, ein ventraler Bronchus, fehlt selten als ein separater Bronchus. Schliesslich folgt eine Verästelung in einen mediodorsalen und einen ventro-lateralen Ast. Hierdurch wird gefunden, dass 5 Segmente anwesend sind.

Eine Übersicht wird gegeben über die Segmente der rechten Lunge und über die systematische Bronchoskopie der rechten Seite.

## RÉSUMÉ

Poursuivant des recherches antérieures les auteurs décrivent la répartition des segments des lobes moyen et inférieur droits, qui dépend de l'anatomie de l'arbre bronchique. Celle-ci est très constante dans le lobe moyen: la bronche part du côté ventral

et se divise bientôt en deux branches interne et externe. La disposition au niveau du lobe inférieur est beaucoup plus compliquée attendu qu'on y trouve de nombreuses variantes anatomiques. La première grande branche constante, c'est la 1e bronche dorsale, suivie de la bronche cardiaque, qui est habituellement présente; la branche suivante, une bronche antérieure, manque rarement en tant que branche séparée. Enfin vient une ramification en branche postéro-interne et branche antéro-externe. De la sorte on constate la présence de 5 segments.

Exposé de l'agencement des segments, du poumon droit, ainsi que de la façon dont sera exécutée une bronchoscopie systématique de ce côté.

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FROM THE ROENTGEN DIAGNOSTIC DEPARTMENT OF THE UNIVERSITY CLINICS IN LUND
(CHIEF: DR. H. HELLMER, ASSISTANT PROFESSOR)

# THE ROENTGENOLOGIC DIAGNOSIS AND TREATMENT OF INTUSSUSCEPTION IN CHILDREN[1]

by

*Hans Hellmer*

## I. Material and Method

The material treated in this article dates from June 1, 1933 to December 31, 1942, viz. the period of nine and a half years I have been working at the roentgenologic department of the Lund Hospital. It includes all the patients under fifteen years of age in whom the diagnosis of intussusception was made after the administration of an enema of barium sulphate. It thus excludes the cases of intussusception high up in the small intestine discovered by roentgen examination of the intestinal passage, which cases are not amenable to roentgenologic reduction.

During this period all the patients of this age were subjected to roentgenologic examination of the colon with a barium enema whenever there was a question of intussusception. In some of the cases there were *unmistakable clinical signs* of intussusception, in others one or several features pointed to the *possibility* and in others the clinical signs pointed more to other conditions but it was desired to *exclude the possibility* of intussusception.

When a fairly large number of proved cases of intussusception have passed through a hospital and when the staff there has had strong reminders of the condition in earlier publications from the hospital, the surgical and pediatric departments are always on the look-out for intussusception when presented with a child with acute abdominal distress. Many cases in which there are only slight grounds for suspecting intussusception are then subjected to roentgenologic examination.

During this period 335 cases were examined with barium enemas.

[1] Submitted for publication Febr. 15, 1943.

and in 110 cases, covering 93 patients, the diagnosis of intussusception was made. Roentgenologic reduction was attempted in all the cases.

It is beyond the scope of this paper to discuss the factors which influence the proportion between the number of intussusceptions which actually occur and the number of ones detected with the roentgen ray. Suffice it to say that

1) An intussusception need not cause clinical signs.

2) By no means all the cases of intussusception causing clinical signs are subjected to roentgenography.

3) The invagination may have undergone spontaneous reduction by the time the roentgenologist sees the patient.

4) Occasionally the disinvagination may take place so rapidly when the barium enema is given that the roentgenologist has not time to see the condition.

The yearly distribution of the cases during the period from June 1, 1933 to December 31, 1942 is seen from the following table.

*Yearly Distribution of the Cases*

| | | | |
|---|---|---|---|
| 1933 (from June 1 on) | 3 | 1939 | 11 |
| 1934 | 10 | 1940 | 9 |
| 1935 | 9 | 1941 | 10 |
| 1936 | 5 | 1942 | 10 |
| 1937 | 14 | Total | 93 patients |
| 1938 | 12 | | |

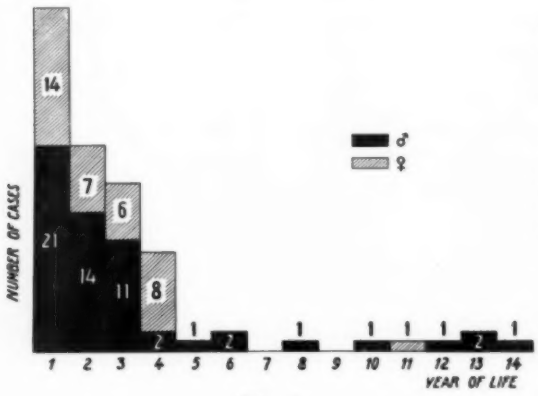



Fig. 1.

Of the 93 patients *57* were *boys* and *36 girls*, making a proportion of *1.55 : 1*.

The age distribution appears from figure 1. All except 10 patients were in the first four years of life. More than a third of the patients were in the first year. There is a marked preponderance of males in the first three years of life.

Regarding the method, I beg to refer to my articles in Nordisk Medicin in 1939, in Roentgenpraxis in 1942 and in Der Chirurg in 1942. I am of the opinion that the whole procedure with the enema and its supervision in the fluoroscopic screen puts great

demands on the skill and judgment of the physician and his nurses, and thus do not at all agree with OLUF JACOBSEN who said in 1942: »There is not much to say about the method, for the administration of the enema and examination through the fluoroscopic screen is a simple task».

I wish to add the following to my previous reports.

We have found that the pressure exerted by the fluid itself is often sufficient for the reduction. It generally amounts to 1 metre. To press the invagination out through Bauhin's valve the pressure is sometimes increased but is never allowed to exceed 1.5 metres. Not until we find that the pressure of the fluid does not give the desired result, do we resort to manual reduction. We have had such successful results with the pressure from the enema during later years, that as a rule we only use manual reduction when the replacement of the invagination back through the ileo-coecal valve meets with great difficulties.

As a proof that the reduction is successful, I have required during later years *that the barium contrast not only pass out into the terminal loop of the ileum after filling the colon with the coecum, but also high up in the small intestine*. When we use the enema container described in my aforementioned articles, we *always* obtain this filling when the reduction is successful. Thus during recent years we have not had to make several post-examinations with renewed enemas as used to be necessary when the contrast material did not pass out through Bauhin's valve.

Regarding the question as to the period the attempts at reduction should cover, it is difficult to set an exact maximum time. This must be left to the judgment of the roentgenologist in any one case. I can, however, precisify our current behaviour here by saying that, when we have brought the invagination down to Bauhin's valve and — as is, indeed, often the case — the rest of the reduction meets with difficulties, we do not hesitate to repeat the attempts once or twice, after the child has been carefully dried and allowed to rest a little. I consider this repetition of the attempts fully motivated since our experience has shown that an invagination consisting of small intestine, which from Bauhin's valve reaches up towards the flexura hepatica, has in this way been reduced.

It is of importance to ensure that the roentgen laboratory is well heated. It is then possible for the child to be completely naked, which makes it easier to handle.

If the reduction is definitely unsuccessful, the child must rest during the period before the laparotomy immediately following. The total loss of time from an unsuccessful roentgen reduction usually amounts to 3/4 hour. Sometimes it is less, but at night it can sometimes amount to rather over an hour.

## II. Roentgenologic Diagnosis

When judging the results of treating intussusception in children, it is important to consider the *types* of invagination occurring in the different cases. It is, of course, not so easy to determine the type and place of origin of the invagination by *roentgenologic examination* as it is with *laparotomy*. Different anatomic conditions may give the same roentgen picture. Thus it is easier to classify the cases in which roentgenologic reduction is a failure than where it is a success. It is still more difficult to determine the type from *clinical observations*.

Classification of the cases also requires a clear *definition* of the different types of intussusception. A glance at the literature shows, however, that different authors use different principles for their terminology; hence their different types do not correspond.

Sometimes a complete distinction is not made between primary and secondary invaginations. Thus the term ileo-coecal invagination has come, in the surgical literature, and still more so in the roentgenologic literature, to include invaginations with different points of origin, and often those originating primarily in the small intestine are not carefully weeded from them.

As far back as 1903 CORNER objected sharply in his analysis of fourteen operated cases to the misuse of the diagnosis ileo-coecal invagination. »The ileocoecal variety is the one most frequently diagnosed wrongly. In fact, when examined, its diagnosis rests more on preconceived notions and absence of evidence that the case was really otherwise than upon any real positive fact that indicated its true nature. 'Ileocoecal' has been diagnosed over and over again in cases reduced by manipulation, inflation, injection of water, etc.; where there has been no post-mortem examination; times without number where a hastily reduced gut has been even more hastily replaced in the abdomen, when neither the reduction nor the reduced gut has been observed, and so forth. Such is the state of affairs, that any case diagnosed as ileocoecal requires more steadfast proof than any one diagnosed as enteric or colic, because one feels that the latter is based on actual observation, and that the former is not.» It is unfortunate that, during the forty subsequent years, his critical attitude was totally ignored by many of the authors working with this problem.

Another reason for the differences in the nomenclature used by different authors is the difficulty in drawing a sharp line between different types of invagination originating in the small intestine. The cases are often classified more on the morphologic features at a given point in time than on the conditions immediately preceding or following these features. For example, when a case is called ileo-ileocolic invagination,

the name is based on observations on *one* occasion, and the facts that the invagination was earlier an ileo-iliac invagination and may later change to an ileocolic invagination are not taken into consideration (fig. 2). *Thus the nomenclature has been more static than dynamic.*

I have used the following two principles for classifying my cases.

1) Rational classification of the types of intussusception should, as WILMS pointed out, be based first of all on the place »die bei der beginnenden Einscheidung die Spitze bildet». Only in the second place should regard be paid to the parts of the intestine involved during the course of the invaginating process.

2) It is easier to define the point of origin of the invagination if one keeps to parts of the intestine which are well distinguishable both from an anatomic and a roentgenologic standpoint.

Thus I have divided my cases into *1) invaginations starting in the mucous membrane of the large intestine and 2) invaginations starting in the mucous membrane of the small intestine.*

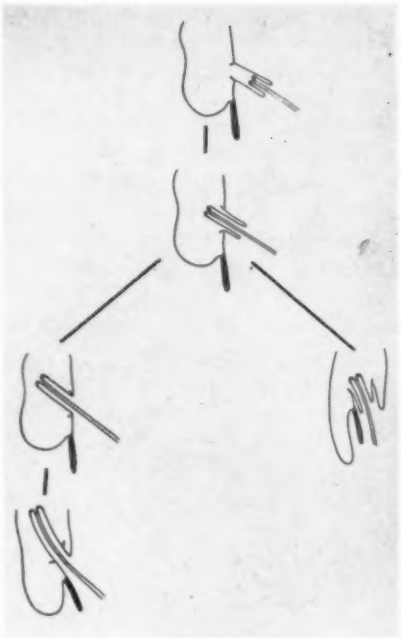


Fig. 2. Schematic representation of how intussusception at the ileo-iliac stage may develop. At the top of the diagram is seen the invagination at the ileo-iliac stage. It develops into the ileo-ileocolic stage, which may then continue either into the ileo-colic stage (to the left in the picture) or into the ileo-ileocolic-ileocoecal stage. In the latter stage the intussusception has acquired a colonic component, which may also happen when the ileo-colic stage progresses further (farthest down to the left).

The classification was based on a re-examination of the roentgen pictures. We have been so concerned during the course of the years with obtaining a good therapeutic result that the interest in diagnosing the type of invagination has often been thrust into the background. The result is that in many of the cases originating in the region where the small intestine passes into the large intestine it is not possible to say if the primary invagination took place in the mucosa of the small or large intestine. These cases amount to 51 (fig 25).

If, in addition to the aforementioned classification, it is desired to state what parts of the intestine are involved at the time of examina-

tion, it should be said that the intussusception is at such and such a *stage*, not that it is of such and such a type, for one type of invagination often develops into another and when disinvagination occurs must return through earlier stages of development. The classification into stages brings out the dynamic nature of the invaginating process.

In cases where an intussusception originating primarily in the small intestine causes a secondary invagination in the large intestine, I say that there is a *colonic component* in the invagination. It is generally impossible to see from the roentgen picture the way the large intestine has become involved.

### *A. Intussusceptions starting in the large intestine*

In seven cases, comprising three patients, the intussusception originated in the colon.[1] In one of the cases (case 72—76),[2] that of a 2-year-old boy, there was a pedunculated polyp in the floor of the coecum, later removed at operation. The patient had four recurrences during the course of twelve days. In case 31, a 12-year-old boy, there was a polypoid formation in the flexura lienalis, and in case 1, a 10-year-old girl, there was a filling defect in the coecal floor. When this last patient was re-examined nine years later, the defect was no longer visible. It is likely, therefore, that it was due to local oedema in the coecum remaining after the disinvagination.

Fig. 3. Case 72—76. Intussusception starting in the coecal floor (polyp). The barium passes about 4 cm. forward on the outer surface of the intussusceptum.

The roentgen picture in the first of these cases shows that, in a case of intussusception beginning in the coecal floor, the contrast substance can penetrate fairly far forward on to the outer surface of the intussusceptum (fig. 3). It does not end abruptly in a cupola effect. *Whether the contrast medium spreads out in a haze around the intussusceptum or whether it stops suddenly in a cupola effect depends not only upon the thickness and shape of the intussusceptum but also upon the pressure with which the contrast medium is introduced.*

### *B. Intussusceptions starting in the small intestine*

In 51 of the 58 cases in which the site of origin of the intussusception was established, it was found to lie in the small intestine.

[1] I include the coecum in the colon, like BROMAN and others.

[2] For reasons of space, the case histories are not published. They are available at the roentgen diagnostic department in Lund.

As far back as 1873, LEICHTENSTERN pointed out the great importance of the small intestine in giving rise to a large number of invaginations. He assumed that these cases started by the mucosa in the small intestine near Bauhin's valve penetrating into the large intestine, as in the case of rectal prolapse. This initial development differs from that in an invagination in that in the prolapsed double cylinder new parts of the inner cylinder continually passed over on to the outer cylinder. In such a case the apex is not constant, as in the case of an invagination, but continually shifting. Not until a later stage, said LEICHTENSTERN, does the apex become fixed and real intussusception develop.

In 1897 D'ARCY POWER made an anatomic investigation of the ileocoecal region. Examining forty-four cases, he tried to determine the factors which tend to cause the development of intussusception. He mentioned in his report that »in a few cases the mucous membrane of the ileum was distinctly prolapsed into the large intestine». I am attaching a case (fig. 4 a, b) from a study I am engaged in at present on the anatomy of the ileocoecal region in children, which gives a good illustration of a prolapse of the ileac mucous membrane.

WILMS, although he did not agree with LEICHTENSTERN as to the primary development, also considered that many of the invaginations occurring in the ileocoecal region began in the small intestine.

It is of the greatest importance when trying to judge the frequency of different forms of invagination from the cases of other authors, to give most attention to the operated cases, especially the ones which the author has himself examined. Such cases are of much more value than the large series of cases where the data are obtained from the records of different hospitals or from earlier reports. CORNER made extremely careful observations in fourteen operated cases. He stressed the importance of making a thorough examination during the operation of the portion of the ileum nearest the coecum. He considered that this part of the intestine was most often the seat of the primary invagination.

WICHMANN found in his series of operated cases, collected from different sources during 1891 to 1902, that in 502 cases of children up to two years of age, there was an invagination of the small intestine into the large intestine in 91 per cent of the cases and an invagination of small intestine into small intestine in 5 per cent.

PERRIN and LINDSAY found that in 354 cases operated on at the London Hospital during 1903 to 1920, 164 or 45.1 per cent originated from the small intestine.

In his report of 50 operated cases in 1924 THOMPSON said: »The majority of cases started as ileo-ileal (60 per cent), in which the last portion to be reduced was ileum». If this author's four cases which he called ileocolic are added on, the percentage rises to 68.

Fig. 4 a. The anterior and posterior halves of the frontally divided ileocoecal region of a 2-day-old boy (died from rupture of the tentorium cerebelli). The invaginated mucosa of the small intestine shows up distinctly through its imbibition of meconium.

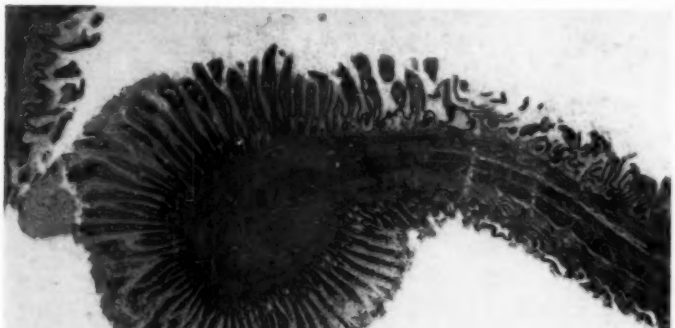


Fig. 4 b. Microscopic section through the lower valvular lip. The lumen of the ileum lies above, the lumen of the coecum below. The mucosa of the ileum prolapses over on the large-intestine side of the valve.

In his book »The involuntary nervous system in relation to abdominal diseases» of 1927, FRASER mentioned that 295 out of 300 cases of intussusception operated upon at the Edinburgh Children's Hospital showed distinct signs after reduction of the condition having started in the ileum.

LAURELL stated in his work of 1932 on the roentgenologic diagnosis of intussusception of the small intestine, and on the manner of development of intussusception generally, that several authors had found that the ileocoecal invaginations often developed on the basis of a primary intussusception in the small intestine: »Vom therapeutischen und diagnostischen Gesichtspunkt aus ist es interessant zu wissen, wie oft die ileocoecalen Invaginationen als eine Dünndarmsinvagination beginnen.» He reasoned that, since most cases of intussusception in the small intestine begin in the terminal ileum, it should be possible by means of a barium enema to detect them at the stage when the apex is at the orifice of the valve or in the lowest part of the ileum. He then proved that this was true in a case of a 30-year-old man where he demonstrated an intussusceptum originating in a Meckel diverticulum when the apex was at the valvular orifice. After the patient had defecated, the apex was found in the ileum a short distance from the valve. This was the first time that a roentgen picture of an intussusceptum at the small-intestine stage was published.

In 1934 SJÖSTRÖM collected 38 cases of intussusception in children. Roentgenologic reduction had been attempted in all the cases. Sixteen of the children had undergone operation. Only 7 of the 16 showed origin from the small intestine. None of the cases diagnosed from the roentgen picture alone are given as originating from the small intestine, but SJÖSTRÖM stressed the difficulty of classifying the type in a case of successful roentgenologic reduction. Even as regards the operated cases, 8 of which are listed as ileocoecal, the author stated that it can also be difficult at operation to establish from what point the intussusception begins, an opinion which is also held by other surgeons, HARRENSTEIN, for example.

In 1942 EDBERG described cases he had himself observed at operation or at roentgen examination during a period of ten years, and in 66 of his cases, covering 51 patients, the type of invagination was established. Of the 66 cases, 40 began in the small intestine. In EDBERG's earlier series of 1928, 27 out of 65 operated cases with an established site of origin were traced to the small intestine.

### *The roentgenologic findings in this material*

The most interesting part of the roentgen examination is when the apex is moved over from the colon to the ileum.

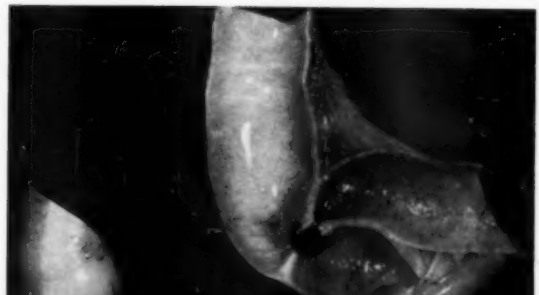


Fig. 4 a. The anterior and posterior halves of the frontally divided ileocoecal region of a 2-day-old boy (died from rupture of the tentorium cerebelli). The invaginated mucosa of the small intestine shows up distinctly through its imbibition of meconium.

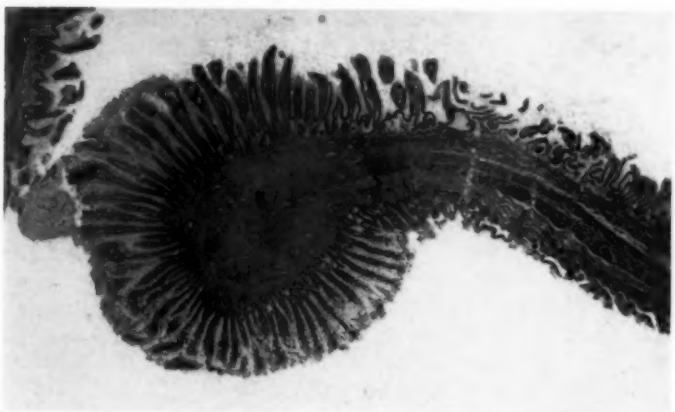


Fig. 4 b. Microscopic section through the lower valvular lip. The lumen of the ileum lies above, the lumen of the coecum below. The mucosa of the ileum prolapses over on the large-intestine side of the valve.

In his book »The involuntary nervous system in relation to abdominal diseases» of 1927, FRASER mentioned that 295 out of 300 cases of intussusception operated upon at the Edinburgh Children's Hospital showed distinct signs after reduction of the condition having started in the ileum.

LAURELL stated in his work of 1932 on the roentgenologic diagnosis of intussusception of the small intestine, and on the manner of development of intussusception generally, that several authors had found that the ileocoecal invaginations often developed on the basis of a primary intussusception in the small intestine: »Vom therapeutischen und diagnostischen Gesichtspunkt aus ist es interessant zu wissen, wie oft die ileocoecalen Invaginationen als eine Dünndarmsinvagination beginnen.» He reasoned that, since most cases of intussusception in the small intestine begin in the terminal ileum, it should be possible by means of a barium enema to detect them at the stage when the apex is at the orifice of the valve or in the lowest part of the ileum. He then proved that this was true in a case of a 30-year-old man where he demonstrated an intussusceptum originating in a Meckel diverticulum when the apex was at the valvular orifice. After the patient had defecated, the apex was found in the ileum a short distance from the valve. This was the first time that a roentgen picture of an intussusceptum at the small-intestine stage was published.

In 1934 SJÖSTRÖM collected 38 cases of intussusception in children. Roentgenologic reduction had been attempted in all the cases. Sixteen of the children had undergone operation. Only 7 of the 16 showed origin from the small intestine. None of the cases diagnosed from the roentgen picture alone are given as originating from the small intestine, but SJÖSTRÖM stressed the difficulty of classifying the type in a case of successful roentgenologic reduction. Even as regards the operated cases, 8 of which are listed as ileocoecal, the author stated that it can also be difficult at operation to establish from what point the intussusception begins, an opinion which is also held by other surgeons, HARRENSTEIN, for example.

In 1942 EDBERG described cases he had himself observed at operation or at roentgen examination during a period of ten years, and in 66 of his cases, covering 51 patients, the type of invagination was established. Of the 66 cases, 40 began in the small intestine. In EDBERG's earlier series of 1928, 27 out of 65 operated cases with an established site of origin were traced to the small intestine.

### *The roentgenologic findings in this material*

The most interesting part of the roentgen examination is when the apex is moved over from the colon to the ileum.

Fig. 5. Case 39. The apex directly below the hepatic flexure. The intussusceptum, which is much narrower than the colon, is surrounded by contrast medium except inferomedially where it passes into the valvular region.

In two cases the intussusceptum was shifted back to the ileo-iliac stage, and the rest of the reduction was done operatively. In case 39 the apex was met with first in the hepatic flexure. The contrast medium passed forward on to the outer surface of the intussusceptum and filled the coecal pole and the appendix (the latter is not visualized in the attached pictures (fig. 5). The intussusceptum, which consisted of small intestine, was easily brought down to Bauhin's valve and, after increased pressure on the fluid and manual pressure, it passed out into the ileum. There the apex was visualized about 7 cm. oral to Bauhin's valve. The contrast matter passed forward a short distance on the outer surface of the middle cylinder (fig. 6 a). On laparotomy it was found that the disinvagination had continued, the apex then being situated about 30 cm. oral to Bauhin's valve. In case 68 the barium met the apex in the rectum. The intussusceptum was pressed back without any great difficulty to the region of Bauhin's valve (fig. 7). The barium filled the coecum. By means of increased pressure and manual manipulation, the apex was brought out into the ileum where it stopped 3 to 4 cm. oral to Bauhin's valve (fig. 8). Post-mortem examination showed that the intussusception began in a Meckel diverticulum.

The terminal roentgen picture in these two cases corresponds entirely with one LAURELL described in 1932 of an intussusception in the small intestine with the apex in the ileum a short way from Bauhin's valve and also with the picture I obtained in 1930 when I first had the opportunity of following an intussusception out to the ileo-iliac stage with a barium enema. This picture is given in figure 5 of SJÖSTRÖM's article in Acta Chirurgica Scandinavica of 1934.

In three cases the contrast medium passed out into the ileum on the outer surface of the middle cylinder (intussusceptum) while the apex remained at the orifice of Bauhin's valve. A roentgen picture was then

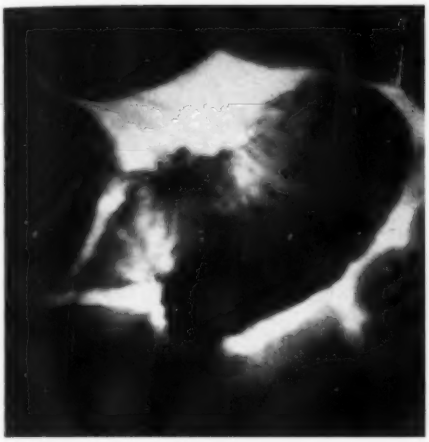


Fig. 6 a.

Fig. 6 b.

Fig. 6 a. Case 39. The intussusceptum has been pressed through the valvular orifice out into the ileum. The apex is now about 7 cm. oral to Bauhin's valve. The contrast medium passes forward at least 6 cm. on the outer surface of the middle cylinder.

Fig. 6 b. Schematic representation of figure 6 a.

Fig. 7.

Fig. 8.

Fig. 7. Case 68. The apex on a level with Bauhin's valve.

Fig. 8. Case 68. The intussusceptum has been pressed through the valvular orifice out into the ileum, where it stops with its apex 3—4 cm. oral to Bauhin's valve. The contrast medium passes forward a short distance on the outer surface of the middle cylinder.

Fig. 9.

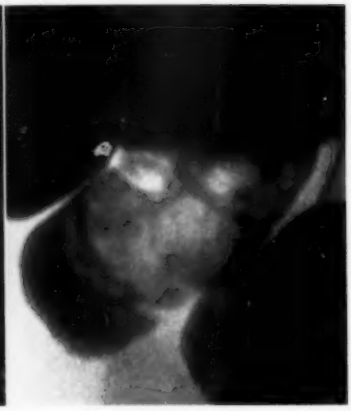


Fig. 10.

Fig. 9. Case 7. The apex in the hepatic flexure. The contrast medium surrounds the apex to a distance of about 3 cm.

Fig. 10. Case 7. The apex has now been pushed down into the ascending part of the colon and the contrast fluid fills the coecal pole.

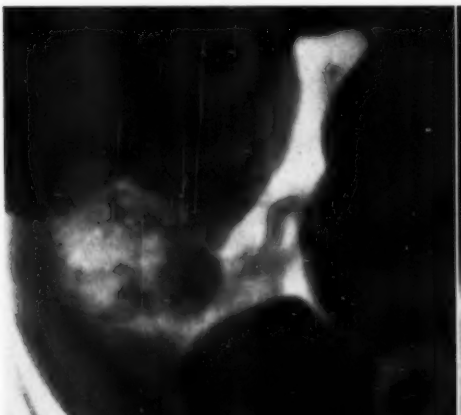


Fig. 11.

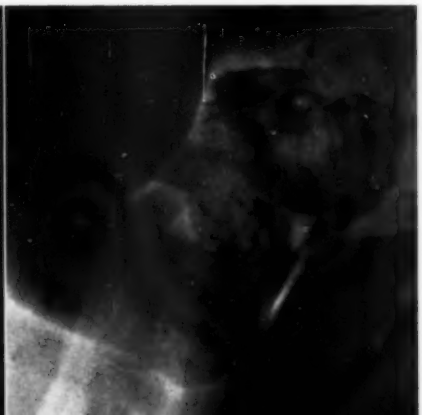


Fig. 12.

Fig. 11. Case 7. The intussusceptum has been pushed still farther oralward, only 5 cm. now being left in the large intestine. The appendix is filled with contrast.

Fig. 12. Case 7. The part of the intussusceptum jutting into the colon is now only a little larger than a walnut. The barium has passed out through the valvular orifice and goes 5—6 cm. forward in a thin layer around the intussusceptum. This part of the intussusceptum shows a distinct shell-shape.

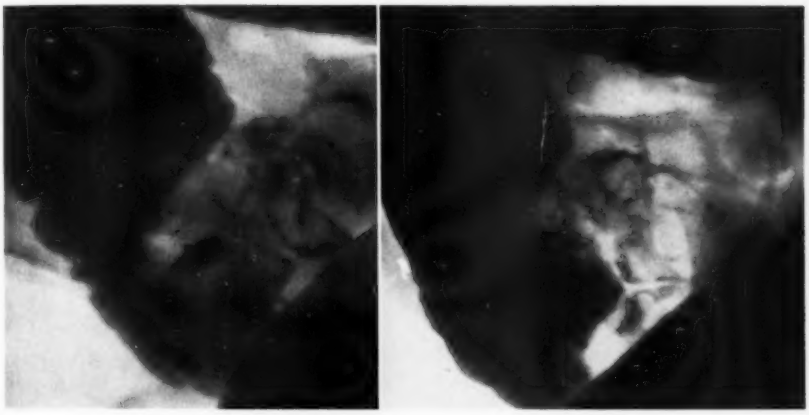


Fig. 13. Fig. 14.

Fig. 13. Case 25. The part of the intussusceptum jutting into the colon causes a walnutsized, rounded filling defect. The barium goes out through the valvular orifice into the ileum, enveloping the intussusceptum in a thin layer.

Fig. 14. Case 25 (at an attempt at reduction five hours later). The intussusceptum has now been pushed oralward, the apex lying in the valvular orifice.

obtained of an intussusception at the ileo-ileocolic stage. In case 7 the apex was moved from the hepatic flexure (fig. 9) to Bauhin's valve (fig. 10), and the contrast medium then continued into the ileum on the outer surface of the middle cylinder (fig. 11). A part of the intussusceptum appears shell-shaped in the ileum (fig. 12), a formation also observed in the operation immediately afterwards. A similar picture was shown by case 25, in which a barium enema led to complete reduction ten hours after the first attempt. The picture in this case shows how the apex jutting through Bauhin's valve caused a walnut-sized, round defect, while the contrast fluid pressed out into the ileum and surrounded the middle cylinder (figs. 13 and 14). A little while before the reduction was completed in case 13, the apex jutting through Bauhin's valve caused a similar defect to that in the foregoing case and minimal amounts of contrast medium were sprinkled out in the ileum on the external surface of the middle cylinder (fig. 15). The roentgen picture in these cases is the same as the one LAURELL published of one stage in his roentgen examination of an invagination starting in the small intestine (fig. 11, p. 378 of LAURELL's article).

We often observed this filling defect in the colon originating from the valvular region towards the end of the reduction. Its length in the colon varied according to the stage of the reduction when the roent-

Fig. 15. Fig. 16.

Fig. 15. Case 13. While the apex is still in the colon, a small amount of contrast medium sprays out into the ileum, where it is seen lying in fine streaks between the mucosa of the middle and outer cylinder.

Fig. 16. Case 89. The apex in the middle of the ascending colon. The intussusceptum which is apparently narrower than the colon is surrounded by contrast matter except at the site of the distended valvular orifice. The appendix is filled with contrast matter. Note the medial concave bend of the coecum and ascending colon (LAURELL).

genogram was taken. Sometimes, as in case 89, it reached up to the middle of the ascending colon (fig. 16). In this case the contrast fluid surrounded the intussusceptum on all sides except at the site of the dilated valvular orifice. After a few energetic attempts with taxis the reduction succeeded, and the contrast medium passed far up into the small intestine (fig. 17). In fig. 18 the apex met with in the right part of the transverse colon has been brought down to Bauhin's valve, where it causes a filling defect the size of a thumb. Fig. 19 shows the state a few minutes later, when the contrast medium has passed into the small intestine and the invagination is completely reduced. In case 44 we see the filling defect due to the intussusceptum shortly before (fig. 20) and at the moment (fig. 21) the apex passes the valvular orifice. A stage of the disinvagination immediately preceding the last-mentioned is seen in the picture from case 10, where the apex has just begun to pass through the widened valvular orifice (fig. 22). In the pictures from case 21 we

Fig. 17. Case 89. The contrast medium has continued high up into the small intestine. The intussusception is clearly reduced.

Fig. 18. Fig. 19.

Fig. 18. Case 109. The apex causes a small filling defect by Bauhin's valve.
Fig. 19. Case 109. After complete reduction.

Fig. 20.

Fig. 21.

Fig. 20. Case 44. The intussusceptum still juts through the valvular orifice a few centimetres up in the colon.
Fig. 21. Case 44. The apex is just passing the valvular orifice.

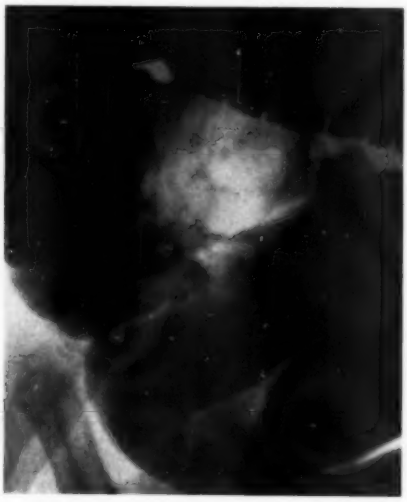


Fig. 22. Case 10. The apex is just beginning to pass through the widened valvular orifice.

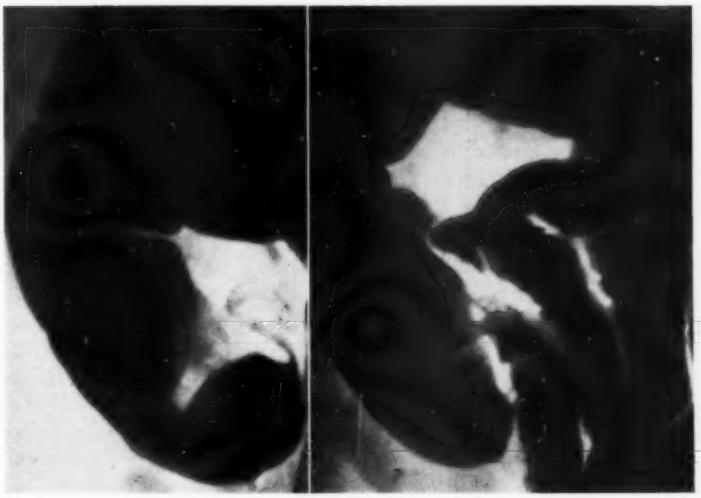


Fig. 23. Fig. 24.

Fig. 23. Case 21. Directly before its passage through the orifice the apex causes a defect, the size of a finger-tip, in the contrast shadow. The filling defect caused by the valve, triangular in shape, is also distinctly visualized.

Fig. 24. Case 21. After complete reduction, the valve causes a triangular filling defect. The corner of the triangle facing the colonic lumen is sharper than in figure 21, showing that the labia have come together again.

see first how the apex causes a filling defect the size of a finger tip immediately before its passage through the orifice (fig. 23) and then how the valve is still visualized as a triangular defect when the reduction is completed (fig. 24). The corner of the triangle facing the lumen of the colon is then much sharper than in the first picture, showing that the labia have come together again.

In 18 of the 51 cases where the intussusception originated on the side of the small intestine, this condition was proved at operation. In the remaining 33 cases there was a roentgen picture which, like the ones now described, showed that the last part of the intestine to be disinvaginated was composed of small intestine.

### III. On the value of roentgenologic reduction of intussusception in children

The first cases of intussusception reduced with a barium enema were published in 1927. In their work »Über das Bild der akuten Darminvagination bei Röntgenuntersuchung und über Desinvagination mit

Hilfe von Kontrastlavements», the Swedish authors OLSSON and PALLIN described in detail three cases in which the invagination was pushed back in the oral direction by a barium enema. In one case the observation was made when the patient was undergoing roentgen examination for suspected intussusception. In the other two cases the barium was used purposely as a reducing agent. In these two cases the authors filled the colon entirely and after the roentgen examination the patients became free from symptoms. In the first-mentioned case, one originating from the coecum, there was a possibility, the authors said, that the last stage of the disinvagination occurred during the laparotomy performed after the roentgen examination. They did not use narcosis. In the same year an American author, RETAN, published a case of intussusception which he had reduced with a barium enema. POULIQUEN and DE LA MARNIERRE described a case, also in 1927, in which they reduced an intussusception with a barium enema; they pressed the contrast medium out into the small intestine, and thus assured themselves that complete reduction had been effected. This method constitutes an improvement over the old, well-known method of reducing intussusception with enemas of water. But, in contrast to this old method, the barium allows the investigator to follow the disinvagination step by step, and so this improvement meant a new era in the treatment of intussusception in children.

The first large collection of cases of roentgenologic reduction of intussusception in children was published in 1934 by SJÖSTRÖM, who described 38 cases from the surgical department of the university clinics in Lund. Roentgenologic reduction was attempted in all the cases and was successful in 22 of them.

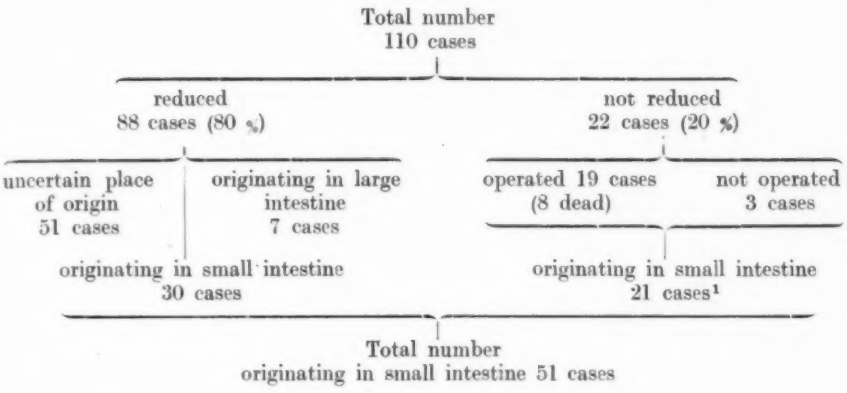
Non-operative methods of reduction have long been subjected to criticism. After a careful analysis of HIRSCHSPRUNG's results, WILMS warned strongly against blind manipulation of any kind. Even since roentgen supervision of the non-operative method has been introduced, some authors still advocate operation as normal method. OBST summarized the advantages of the surgical over the roentgenologic method, as he saw them, in his monograph »Über die Darminvagination und ihre Probleme» in 1937.

The *site of origin of the intussusception* and the *therapeutic results* in my cases is seen from the figure 25.

It is seen from the foregoing that 88 out of the 110 cases were reduced by a barium enema, given under fluoroscopic supervision. Nineteen of the non-reduced cases were subjected to operation. In 3 cases a persistent intussusception was overlooked in the roentgen examination, but spontaneous reduction took place later.[1]

[1] These cases will be described in a separate report.

Fig. 25.


Total number
110 cases
reduced
88 cases (80 %)
not reduced
22 cases (20 %)
uncertain place of origin 51 cases
originating in large intestine 7 cases
operated 19 cases (8 dead)
not operated 3 cases
originating in small intestine 30 cases
originating in small intestine 21 cases[1]
Total number
originating in small intestine 51 cases

Of the 88 cases reduced with roentgen, 7 originated from the colon and 30 from the small intestine. In the other 51 cases it was not possible to see exactly on re-examination of the pictures where the invagination started. In one of the operated cases the records do not give definite information as to whether the intussusception began in the small intestine or whether the small intestine was secondarily involved.

The following table gives the data from the operated cases.

| Case no. | Age | Duration | Ileus Rtg. | Observations during enema | | Site of origin on small intestine discovered at operation or autopsy | Outcome |
|---|---|---|---|---|---|---|---|
| | | | | Initial | Terminal | | |
| 2 | 4/12 | 10 hrs. | 0 | Hepatic flexure | Small intest., filling coecum & lower part of ascending colon | 7 cm. from Bauhin's valve | Death |
| 4 | 6/12 | 28 hrs. | + | Rectum | Sigmoid flexure | 5 cm. from Bauhin's valve | Death |
| 7 | 2½ | 24 hrs. | 0 | Hepatic flexure | Terminal ileum with apex jutting into the colon | 10 cm. from Bauhin's valve | Health |
| 8 | 3/12 | 24 hrs. | + | Transverse colon | Transverse colon (no change) | Not given | Health |
| 15 | 8/12 | 12 hrs. | + | Transverse colon | Small intest., filling coecum & lower part of ascending colon | 1 cm. from Bauhin's valve | Death |
| 35 | 3 | 9 hrs. | 0 | Ascending colon | Terminal ileum with apex jutting into the colon | 25 cm. from Bauhin's valve | Health |
| 36 | 8/12 | 4 days | + | Flexure lienalis | Small intest. in coecum & ascending colon to hepatic flexure | Not given | Death |
| 39 | 3 | 6 hrs. | 0 | Hepatic flexure | Right out into the ileum, 7 cm. from Bauhin's valve | 30 cm. from Bauhin's valve | Health |

[1] One operated case is excluded because the site of origin is uncertain.

| Case no. | Age | Duration | Ileus Rtg. | Observations during enema | | Site of origin on small intestine discovered at operation or autopsy | Outcome |
|---|---|---|---|---|---|---|---|
| | | | | Initial | Terminal | | |
| 50 | 4/12 | 1½ days | + | Rectum | Transverse colon | Uncertain if primary in small intest. | Health |
| 51 | 7/12 | 2½ days | + | Transverse colon | Small intestine in coecum and ascending colon | 20 cm. from Bauhin's valve | Death |
| 54 | 3/12 | 3 days | + | Anus | Transverse colon | Directly oral to Bauhin's valve | Death |
| 59 | 1½ | 4 hrs. | 0 | Hepatic flexure | Small intestine in coecum and ascending colon | 30 cm. from Bauhin's valve | Health |
| 68 | 4/12 | 4 days | + | Rectum | Right out into the ileum, 3—4 cm. from Bauhin's valve | 20 cm. from Bauhin's valve (Meckel) | Death |
| 71 | 2½ | 4 hrs | 0 | Hepatic flexure | Small intestine in colon nearest Bauhin's valve | 30 cm. from Bauhin's valve | Health |
| 77 | 11/12 | 19 hrs. | 0 | Descending colon | Small intestine in colon nearest Bauhin's valve | 7 cm. from Bauhin's valve | Health |
| 82 | 8/12 | 27 hrs. | + | Ascending colon | Small intestine in colon nearest Bauhin's valve | 10 cm. from Bauhin's valve | Health |
| 87 | 1 10/12 | 19 hrs. | 0 | Transverse colon | Small intest., filling coecum & lower part of ascending colon | 30 cm. from Bauhin's valve | Health |
| 98 | 2 | 19 hrs. | 0 | Transverse colon | Small intestine in colon nearest Bauhin's valve | 4 cm. from Bauhin's valve | Health |
| 102 | 7/12 | 1½ days | + | Sigmoid flexure | Hepatic flexure | Good 5 cm. from Bauhin's valve | Death |

Thus in these operated cases the barium enema did not produce complete reduction. In 14 cases it was pushed over to the region of Bauhin's valve, which made it easier for the surgeon to reduce the rest after only a small incision in the abdominal wall.

OBST summarized his criticism of non-operative reduction under roentgenologic supervision in ten points.

1) The method cannot be used in case of intussusception in the small intestine.

2) It makes a retrograde intussusception worse.

3) It cannot be seen whether the disinvagination is complete.

4) It is not possible to know how severely the large intestine is injured, and the intestine may therefore break under the pressure of the enema.

5) The fact that the bloody discharge, vomiting and oedematous tumours may persist makes the clinician uncertain and prolongs the time of waiting before operation.

6) One does not know whether the disinvaginated intestine can continue living.

7) The cause of the invagination is not determined and is therefore not removed.

8) The patient is exposed to considerable strain and to chill.

9) The operation is delayed, for the roentgenologic reduction should, according to OBST, be done by the surgeon.

10) Narcosis is nearly always necessary for roentgenologic reduction, and so patients requiring operation have to undergo narcosis twice.

My experience as related in the present communication allows the following comments on OBST's points.

Point 1) The method can very well be used for intussusception starting in the small intestine. In the case of intussusception starting from the small intestine where complete reduction is not effected, the partial reduction produced simplifies the subsequent operation by calling for only a small incision in the abdomen.

Point 2) This criticism is justified. But it is of no great practical importance, as retrograde intussusception is rare.

Point 3) During the first part of the decade, there were three cases in which the reduction seemed to be complete, but was not. In two cases the operation was delayed by the roentgenologic procedure (both patients were discharged healthy). In the third case the roentgenologic reduction was completed ten hours afterwards. To these are added the 3 cases where a persistent intussusception was completely overlooked. After I made it a rule that the barium enema go high up in the small intestine before the reduction be pronounced complete, we had no more cases of this kind.

Point 4) This statement is correct. However, there is no case of perforated intestinal wall in my material.

Point 5) See the comments to point 3.

Point 6) This is an unavoidable limitation of the roentgenologic method.

Point 7) Local pathological changes in the intestinal wall can be diagnosed without difficulty roentgenologically. On the other hand, it is a well-known fact that small, soft processes arising in the mucosa may be overlooked by the surgeon. It is best to remove lesions of this kind during a symptom-free interval.

Point 8) Apart from the danger of chill, which can easily be avoided, this objection is justified and of great weight. We have observed transient, collapse-like conditions in the small infants during the treatment, but they soon pass over. We have sometimes observed that the child's

condition grew worse during the roentgenologic procedure in the cases where laparotomy had to be done afterwards.

There is no question that roentgenologic reduction puts a great strain on the small children because of the fairly sudden and large changes in pressure it causes in the abdominal cavity. The clinician should not, therefore, go on too loose indications when sending small children for examination with a barium enema. Before giving the enema, the roentgenologist should submit the thorax and abdomen to fluoroscopy, and try to eliminate pathologic processes there, particularly pneumonia. If the stomach is greatly distended with gas, it is best to pass a sound down into it first. In this connection, it should also be mentioned that in the cases where appendicitis cannot be excluded, extreme caution should be observed when giving the enema and taxis should never be used.

Point 9) The loss of time occasioned in the cases which have to be operated on later, is negligible. It is obvious that the roentgenologist should perform the roentgenologic work, just as the surgeon should do the operative work.

Point 10) Narcosis was not used in any of my cases.

## SUMMARY

A report is given of 110 cases of intussusception in children. In every case it was attempted to reduce the invagination with a barium enema given under fluoroscopic observation. In 88 cases, or 80 per cent, the reduction was successful. In 19 cases where it was a failure, operation was performed, with a fatal outcome in 8 cases.

In 51 cases, 30 of which were reduced with a barium enema, the intussusception had started in the small intestine. In 7 cases the invagination began in the colon. In 52 cases the place of origin of the intussusception was not ascertained.

## ZUSAMMENFASSUNG

Der Verf. berichtet über ein Material von 110 Fällen von Invaginationen im Kindesalter. In sämtlichen Fällen wurde die Reposition mittels Kontrasteinlauf unter Röntgenkontrolle versucht. In 88 Fällen (= 80 %) gelang die Reposition. 19 Fälle, in denen die Röntgenreposition missglückte, wurden operiert, davon 8 mit tödlichem Ausgang.

In 51 Fällen, darunter 30 unter Röntgenkontrolle reponierte, ist die Invagination vom Dünndarm ausgegangen. In 7 Fällen ist die Invagination vom Dickdarm ausgegangen. In 52 Fällen konnte der Ausgangspunkt der Invagination nicht klargelegt werden.

## RÉSUMÉ

L'auteur étudie un matériel de 110 cas d'invagination chez des enfants. Dans tous ces cas on a essayé la réduction par lavement opaque sous l'écran radioscopique. Elle a réussi 88 fois (80 %). 19 cas où elle a échoué ont été opérés; 8 d'entre eux se sont terminés par la mort.

Dans 51 cas, dont 30 furent réduits sous l'écran, l'invagination avait son point de départ dans l'intestin grêle. Dans 7 cas elle l'avait dans le colon. Dans 52 cas le point de départ de l'intussusception ne fut pas précisé.

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AUS DEM »RADIUMHEMMET», STOCKHOLM (VORSTAND: PROFESSOR ELIS BERVEN)

# KONSTRUKTION EINER BLENDE ZU THERAPEUTISCHEN ZWECKEN[1]

von

*Erik Lundström*

Bei der Röntgenbehandlung tief liegender Objekte mittels mehrerer konvengierender Strahlenbündel, deren Einfallsfelder auf der Haut dicht aneinander grenzen, besteht die Notwendigkeit jedes einzelne Strahlenbündel so effektiv abzublenden, dass keine Überkreuzung an den Feldgrenzen vorkommt. Dies ist besonders für die Behandlung maligner Tumoren, bei welchen in der Regel eine Bestrahlung bis nahe an die Toleranzgrenze der Haut durchgeführt werden muss, von Bedeutung.

Gegenwärtig wird einerseits die sog. Abdeckungsmethode angewandt wobei die Umgebung des Einfallsfeldes mit strahlenabsorbierendem Material, z. B. Bleiplatten oder Bleigummiplatten überdeckt wird und andererseits kommen Blenden zwischen der Röntgenröhre und dem Patienten in Form eines Tubus oder Diaphragmas, ab und zu mit variierbarer Öffnung, zur Anwendung.

Die erstere Methode erzielt eine besonders effektive Abblendung und kann bei stark unregelmässigen Feldgrenzen angewandt werden. In gewissen Fällen ergeben sich indessen mit dieser Methode Schwierigkeiten, nämlich dann, wenn es sich um Hautfelder handelt, deren Oberflächen von der Horizontalebene stark abweichen und wo die Gefahr bestehen kann, dass die zur Abdeckung verwandten Platten sich während der Behandlung verschieben, wodurch angrenzende Felder freigelegt werden und das Strahlenbündel innerhalb des Körpers eine andere Lage als die beabsichtigte erhält. Diese Methode erfordert ausserdem ziemlich viel Zeit.

Über die genannten Blenden ist zu sagen, dass sie besonders einfach zu handhaben und zeitersparend sind, sie erlauben aber nicht dieselben Möglichkeiten einer Feldvariation wie die Abdeckungsmethode. Bei gewissen Konstruktionstypen, bei welchen die Blendenöffnung nicht bis

[1] Bei der Red. am 9. II. 1943 eingegangen.

Abb. 1.

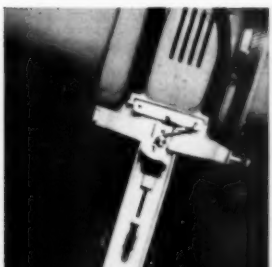

Abb. 2.

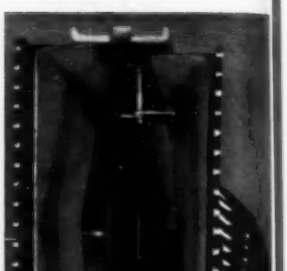

Abb. 3.

zur Hautoberfläche herunterreicht, kann ausserdem die Kontrolle der Feldabgrenzung weniger effektiv werden.

Die Schwierigkeiten beider Methoden ergeben sich besonders deutlich bei der Röntgenbehandlung von Mediastinal- und Lungentumoren, bei welcher eine Anzahl rund um den Thorax liegender Einfallsfelder angewandt wird. Bei der Abdeckungsmethode wiesen die Gummiplatten eine Tendenz auf, entlang der in Längsrichtung des Körpers belegenen Feldgrenzen, besonders bei Flankenfeldern in Rücken- und Bauchlage, abzugleiten. Die gewöhnlich angewandten Blenden können oft nicht an die Form des Einfallsfeldes angepasst werden und die Durchführung der Abblendungskontrolle ist schwierig.

Auf Grund dieser Umstände erhob sich der Gedanke die Abdeckungsmethode mit der Feldabblendung mittels einer spezialkonstruierten Blende zu kombinieren. Die Abblendung entlang der in der Längsrichtung des Körpers liegenden Feldgrenzen könnte mit einer Blende vorgenommen werden, die übrige Abgrenzung, bei der sich keine Schwierigkeiten mit der Abdeckungsmethode ergeben haben, mit Abdeckung.

Die Blende (s. Abb. 1, 2 und 3) besitzt die Form eines rechteckigen Trichters, dessen beide Längswände beweglich sind, wodurch die Breite der Blendenöffnung von 4.5 cm bis 13 cm variiert werden kann. Diese Bewegung wird durch ein, an dem U-förmigen Rahmen, der die beweglichen Blendenwände umgibt, angebrachtes Steuerrad bewerkstelligt. Im oberen Teil der Blende werden die Strahlen in Längsrichtung der

Blendenöffnung abgeschirmt, so dass bei einer senkrecht zur Haut einfallenden Strahlenrichtung und mit einem Haut-Focusabstand von 60 cm die maximale Länge des Einfallsfeldes 24 cm wird, eine Länge, die mit der der unteren Kanten der beweglichen Blendenwände übereinstimmt.

Bei Anwendung der Blende wird der Haut-Focusabstand mittels eines zwischen den unteren Enden des U-förmigen Rahmens angebrachten, nach unten konvexen Bogens, aus unbedeutend strahlenabsorbierenden Material, gemessen; der tiefste Punkt des Bogens, der in der Zentrallinie der Blende liegt, markiert einen Abstand von 60 cm vom Focus. Dieser Abstand wurde gewählt, da die Blende hauptsächlich für die Tiefentherapie bestimmt ist.

Um ein sorgfältiges Anliegen der unteren Kanten der Blende an die Haut zu erhalten, so dass eine Anpassung der Blendenöffnung an die auf die Hautoberfläche aufgezeichneten Feldgrenzen zustandekommt, sowie um eine Verbreitung von Streustrahlen an die angrezenden Behandlungsfelder zu verhindern, sind die beiden beweglichen Blendenwände mit parallel liegenden und in einander gefalzten Metallamellen versehen, die auf die Hautoberfläche herunter geschoben werden können Diese Lamellen bilden somit pallisadenähnliche Verlängerungen der Blendenwände, wobei die Falzung das Herausdringen der Strahlung zwischen den Lamellen verhindert.[1]

Um die Sekundärstrahlung von den inneren Flächen der Blendenwände zu vermindern, wurden diese mit einer 0.5 mm dicken Aluminiumschicht bekleidet.

Bei Kontrollmessungen an der Blende, ausgeführt von Phil. Dr. Sven Benner im Radiophysikalischen Institut des Karolinischen Krankenhauses in Stockholm, ergab sich, dass die Behandlungszeit für Behandlungsfelder mit einer Breite von höchstens 9 cm nicht korrigiert werden musste. Für Felder, die breiter als 9 cm sind, muss die auf die gewöhnliche Weise berechnete Behandlungszeit um 5 % verlängert werden. Es ergab sich, dass die von den Innenwänden der Blende kommende Sekundärstrahlung an der Hautoberfläche nicht 2 % der Direktstrahlung aus dem Röhrenfocus übersteigt.

## ZUSAMMENFASSUNG

Verfasser gibt eine trichterförmige Konstruktion einer zur Therapie angewandten Blende mit viereckiger Öffnung an, deren Breite dadurch variiert werden kann, dass die Längswände beweglich sind. Diese Wände sind mit parallel liegenden und in einander gefalzten Lamellen versehen, die auf die Hautoberfläche herunter geschoben werden

[1] Während der Drucklegung dieser Arbeit hat Verf. die Konstruktion durch das Anbringen von an der Blende befestigten, beweglichen Gabeln, welche die Abgrenzung des Behandlungsfeldes in Längsrichtung ermöglichen, vervollständigt, was die Anwendung des Gerätes, wie es sich gezeigt hat, bei gewissen Fällen erleichtert.

können, wodurch eine effektive Abblendung und eine sorgfältige Feldanpassung ermöglicht wird. Die übrigen Seiten des Behandlungsfeldes werden mittels auf der Hautoberfläche liegenden Bleigummiplatten abgegrenzt. Die Blende ist speziell für die Behandlung von Tumoren im Mediastinum und in den Lungen beabsichtigt.

*Herstellung der Blende:* Järnhs Elektriska AB., Stockholm.

## SUMMARY

The author gives an account of a funnel-shaped diaphragm construction with a rectangular opening for therapeutic use. The breadth of this opening can be varied owing to the movability of the longitudinal walls. These walls are provided with parallel lamellae folded into each other. They can be drawn down to the surface of the skin. In this way an effective shutting-out of the rays and a careful adaptation to the operation field are rendered possible. The other sides of the area under treatment are delimited by means of leaden rubber plates placed on the surface of the skin. The diaphragm is particularly designed for the treatment of tumours in the mediastinum and the lungs.

*Manufacturer:* Järnhs Elektriska AB., Stockholm.

## RÉSUMÉ

L'auteur présente une construction de diaphragme en forme d'entonnoir pour l'usage thérapeutique à l'ouverture rectangulaire dont la largeur peut être variée étant donné que les murs sont mouvants. Ces murs sont munis de lamelles parallelles entaillées les unes dans les autres et qui peuvent être rapprochées à la surface de la peau, rendant possible de cette façon une exclusion effective de rayons et une adaptation de plan exacte. Les autres côtés de la zone de traitement sont limités par des plaques de caoutchouc-plomb placées sur la peau. Le diaphragme est spécialement déstiné au traitement des tumeurs dans mediastinum et les poumons.

*Fabricant:* Järnhs Elektriska AB., Stockholm.